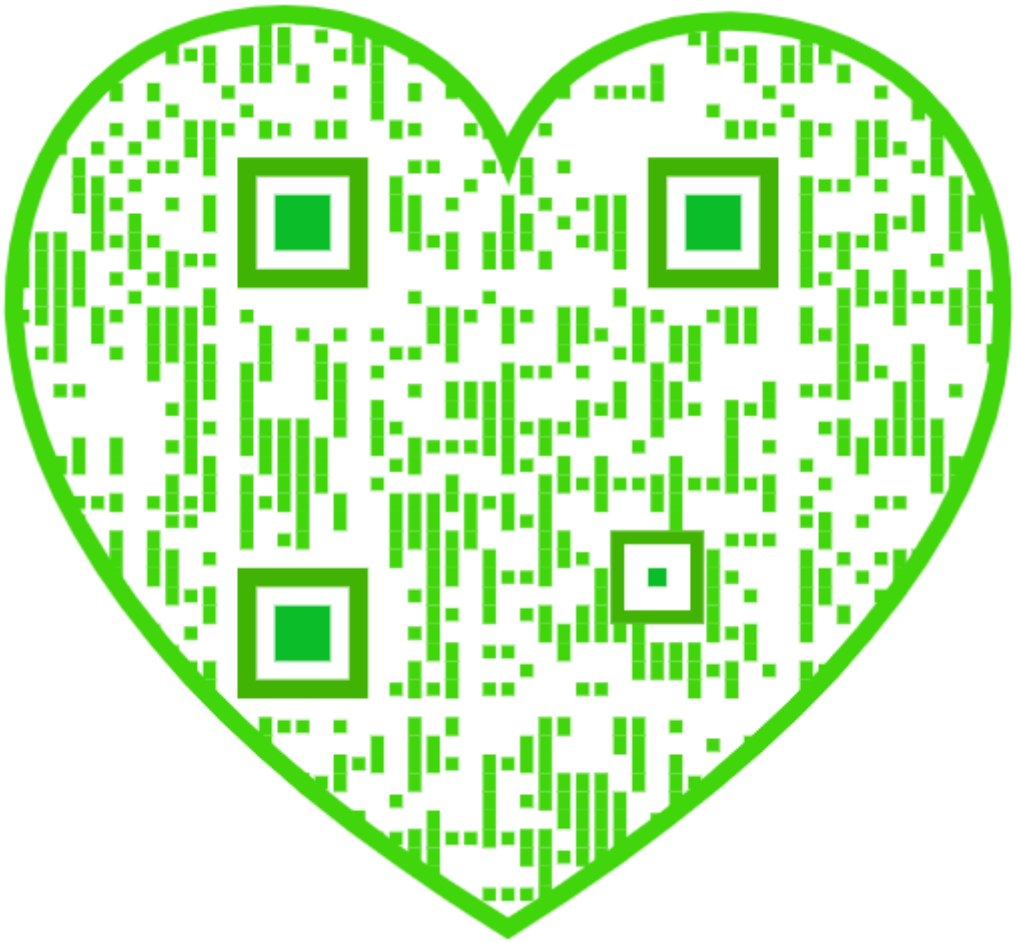

PROTECTION

FROM

FIRE AND THIEVES

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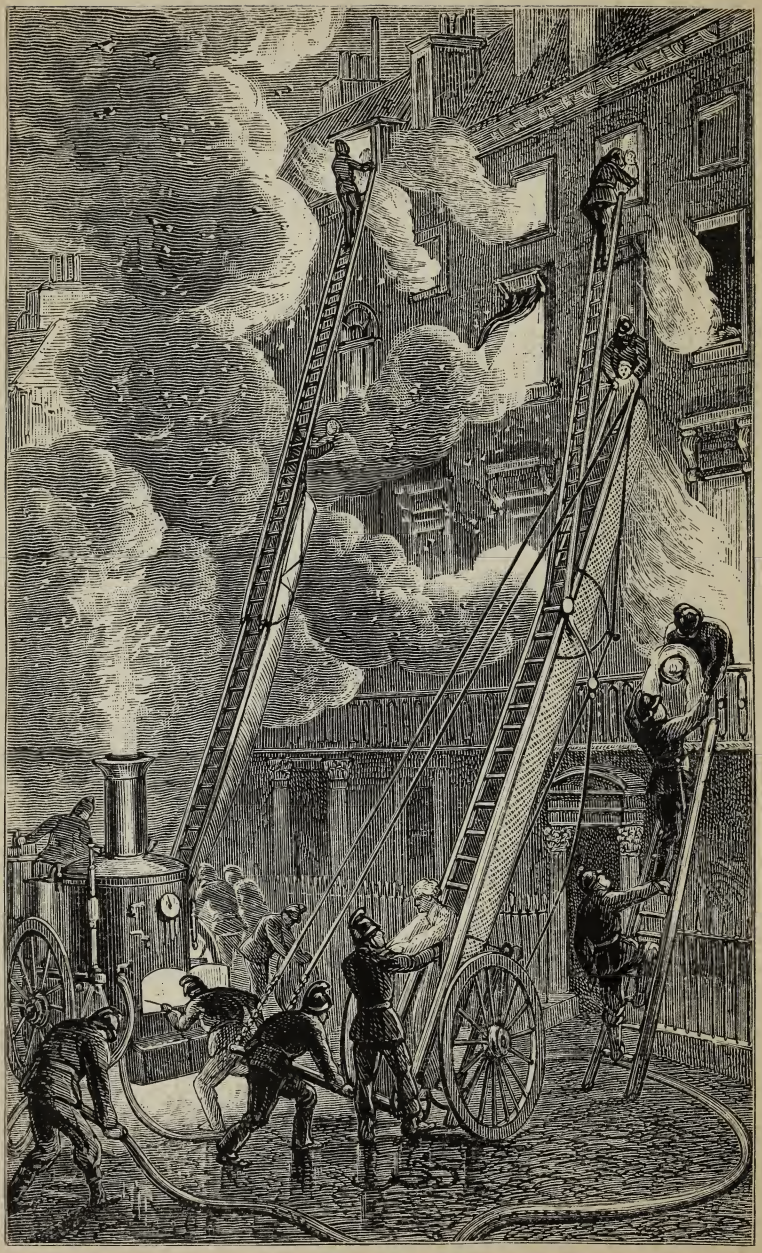


FIRE-ESCAPE AND STEAM FIRE-ENGINE IN ACTION

(From a drawing supplied by the Royal Society for the Protection of Life from Fire)

PROTECTION

FROM

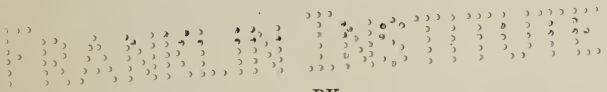
FIRE AND THIEVES

INCLUDING

THE CONSTRUCTION OF LOCKS, SAFES, STRONG-ROOMS, AND FIREPROOF BUILDINGS; BURGLARY, AND THE MEANS OF PREVENTING IT; FIRE, ITS DETECTION, PREVENTION, AND EXTINCTION; ETC.

ALSO

A COMPLETE LIST OF PATENTS FOR LOCKS AND SAFES



BY

GEORGE HAYTER CHUBB

ASSOC. INST. C.E.

CAVENDO TUTUS

LONDON

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PREFACE.

A SMALL book, embracing such subjects as herein treated of, is necessarily somewhat disconnected in its character. In endeavouring to be strictly practical, I fear I have made some portions of the book uninteresting to the general reader; if so, it must be remembered that my chief aim has been to place certain facts before professional and business men, at the same time introducing matter that may be useful to everyone.

I have to offer my best thanks to Colonel Fraser, Colonel Henderson, Captain Shaw, and other Gentlemen, who have afforded me valuable help.

If the importance of protecting life and property becomes in the least degree better understood and appreciated, I shall feel amply repaid for the time and trouble incurred in the preparation of the book.

57 ST. PAUL'S CHURCHYARD, LONDON:
January 1875.

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PROTECTION

FROM

FIRE AND THIEVES.

CHAPTER I.

LOCKS, KEYS, ETC.

When it is known that cash and securities to the value of upwards of six millions are almost constantly kept in the strong-room of one only of the London banks, it will be understood that the safe custody of valuables is a subject of very great importance. Unfortunately it is a matter that has hitherto been greatly neglected by the general public and professional men; and the ignorance on the part of the majority of people as to what is real security, has given rise to this attempt to place a few facts together that will be of general use. The incidents relating to fires, burglaries, &c. are gathered from authentic sources, and from private records that have been compiled during many years.

Although before the last ten years there were but few persons who employed their skill to foil the increasing attempts of safe-breakers, the subject of locks had long been thoroughly considered. The great interest taken

in the lock controversy at the time of the Exhibition of 1851 showed that there were many persons not indifferent to the efforts then made to improve the quality of locks; but it was not until the great burglary at Cornhill, in 1865, that safe-making was fairly investigated by the public. Sufficient proof of this is that in the sixty-four years preceding 1865 only twenty-eight patents for safes were registered, while in the nine years following there were no less than 122. Being myself engaged in the manufacture of locks and safes, I have, of course, some knowledge of their construction; and shall endeavour to state facts that apply to the work of every maker, and my opinions formed by practical acquaintance with this manufacture, and guided by others who have previously written on various branches of the subject.

Locks have, it is said, been in use for above four thousand years in Egypt; anciently these were mostly made of wood, and it is a remarkable thing that the locks that have been in use in the Faroe Islands for many centuries so closely resemble those found in Egyptian catacombs as to be scarcely distinguishable from them. More modern, but considered now to be old-fashioned, are the letter lock and warded lock; later still are the patent locks of Barron, Bramah, Chubb, and others. It is not necessary to describe the variations in all these; it may suffice to say that the most trustworthy are those with levers and tumblers, and protected in other ways from false keys and picks. One chief point of security consists in a lock being so unlike any other that no key but its own will open it; and a 3in. Chubb's drawer lock can have no less than 2,592,000 changes made in its combinations. Mr. Tildesley, in an article published in 'Once a Week,' mentions a lock which had a chime of bells connected with it in such a manner that no sooner was the

skeleton-key of an intruder applied to the lock than the latter began to chime a plaintive air, such as—

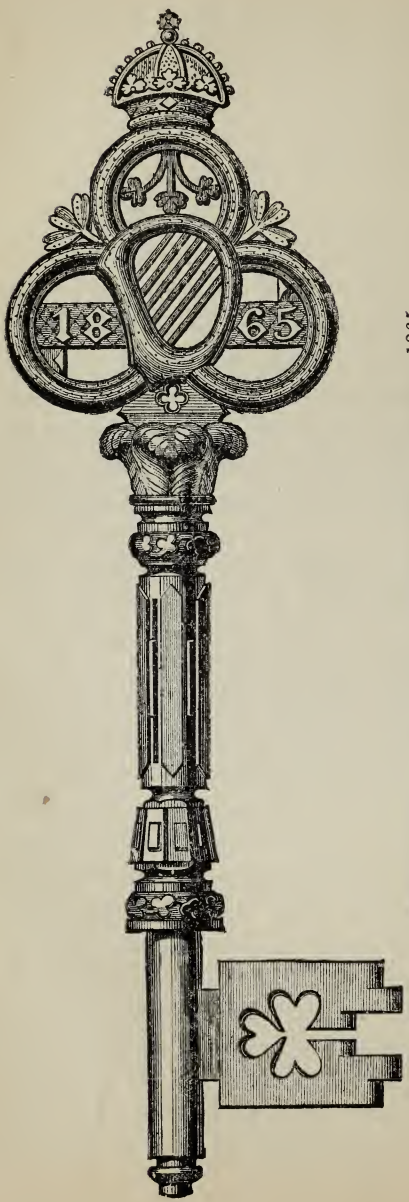
> Home, sweet home;
> Be it ever so humble,
> There's no place like home.

A sentiment in which the housebreaker would doubtless concur as he took his precipitate flight.

It is obvious that locks are only secure so long as their keys are properly taken care of. This is of the utmost importance, for some keys can under favourable circumstances be made merely from a wax impression by a clever workman. Numbers of robberies take place through keys being left about, and to the lock is laid the fault which ought rather to be charged to the careless owner of the keys.

Some people expect perfect impossibilities, and imagine that, having obtained a secure lock, they have done all that is necessary. No lock whatever will guard against culpable negligence with regard to its key; or, as in the famous South-Eastern Railway bullion robbery, the treachery of supposed trustworthy servants. It will be remembered that the notorious lock-picker Agar said the robbery on this railway would be impossible unless copies of the keys could be taken. By the connivance of a guard named Tester this was accomplished, and yet the duplicate keys thus made were useless until Agar had travelled seven or eight times to Folkestone with the chests, altering the keys until they fitted.

Since 1851 many improvements have been made and adopted in Chubb's locks, and more still have been tried and rejected, as interfering with their proper working. Complexity of action in any lock will sooner or later invariably prove fatal to its success. A lock is unlike a

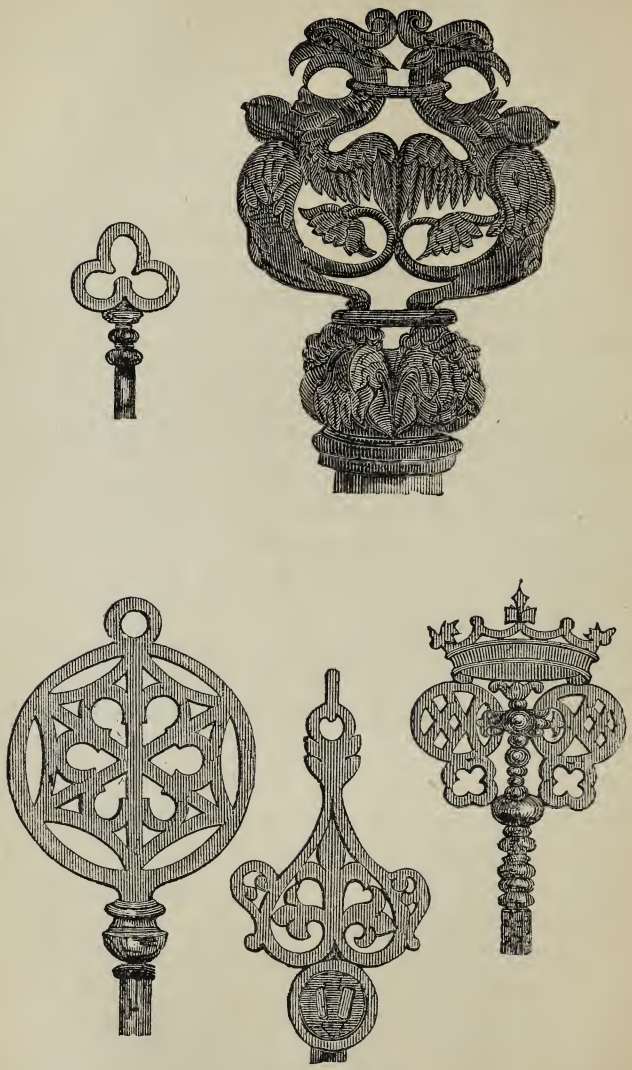


MASTER-KEY OF THE DUBLIN INTERNATIONAL EXHIBITION, 1865.

watch or other delicate machine that is treated with a considerable amount of carefulness; it is subject to every day hard wear and usage. Absolute perfection is perhaps as unattainable in locks as in other matters; nevertheless the present is an age of progress, and a more perfect lock may perhaps be invented some day. Lock patents by scores have appeared within the last twenty-one years; some good, others indifferent or bad in principle, and many of them embracing as new ideas certain principles of construction long since exploded or laid aside. Of those practically defunct (and they are many), my opinion of them is that the ingenuity of the inventors has generally been allowed to over-

run their perception of the before-mentioned fact, viz., that a lock is a very hardworked machine, and that in its construction simplicity is as necessary an element as security.

A good lock cannot have a key made to it unless another key is available to copy from or the lock itself can be broken open. Of this latter fact London burglars have not been slow to avail themselves, and they have tried it in the following manner. It should first be said, for those not acquainted with the mode of securing warehouse and office doors at night, where the buildings are left unoccupied, that such doors are usually fastened with a large rim or mortise lock of the ordinary kind. When this is locked from the outside a small flat bar, that is secured at one end to the door, is put across the keyhole to a staple thereon, fastened by a padlock. The advantage of this plan is that the inner lock cannot be touched, the keyhole being closed while the outer lock is secure; and this padlock being visible, the police in their rounds can tell by a glance under the light of the bull's-eye whether or not it has been interfered with. But there is such a thing as forcing a padlock completely open, with proper appliances; and some clever burglar watching the policeman off his round past a warehouse in Watling Street, one night, wrenched the padlock off and supplied its place by a common one, the outside of which in the dark resembled the one previously on. He then took the patent lock away, got one side off, cut out all the works, so that anything like a key would at once open or close the bolt, fastened the side on as neatly as was possible, took it back to Watling Street again, and watching his opportunity took his own lock off and refixed the empty shell of the patent lock. The purpose in all this was that next night he might at once open the padlock, force the inner lock, and enter the place, while a confederate would doubtless re-



SPECIMENS OF ORNAMENTAL KEY HANDLES, REPRODUCED, BY PERMISSION, FROM 'THE BUILDER.'

place the padlock as if all were right. The success of the scheme depended chiefly upon the padlock or its substitute always being on when the police came round; but, fortunately for the owner of the premises, the attempt was frustrated by the mere chance of the patent lock (now without works and found next day to open rather stiffly) being brought to be examined, when the burglar's attempt was at once discovered. Further revelations of this trick were made to the police by a convict who died while undergoing a long term of imprisonment, and after his disclosures no less than *twenty-seven* padlocks were found in use in the City the works of which had all been taken out, to await the thieves' opportunity, and done in such a clever manner that only the closest inspection could detect it. Two of the locks served thus were on a jeweller's door, which shows the importance of preventing this mode of robbery. Such a well-planned scheme required an improvement to be made in the padlocks, and there is now largely in use what is known as the 'police padlock,' a lock which when once forced asunder is so injured that it cannot be repaired without being entirely re-made, so that if one should be taken off its door by a thief it cannot be put back again.

This is but one of the numberless instances that require the attention and thought of the careful lockmaker; and the other instances that will be given show that with respect to safes it requires yet greater skill to foil the cunning of modern burglars.

The whole of Chubb's locks are made by hand, and differ one from another. The difficulty is not to make them to differ, but when such are needed to make several alike, for a touch of the file will completely alter a lock.

It is so essential for good locks to be totally unlike each other that we continue to make by hand only, although the cost is in consequence high. Machinery

would and does produce well-finished and ser viceable locks, but the changes and combinations cannot vary as with hand-work. 'So extensive are the combinations,[1] that it would be quite practicable to make locks for the doors of all the houses in London with a distinct and different key to each lock, and yet there should be one master-key to pass the whole. A most complete series was constructed some years ago for the Westminster Bridewell, consisting of 1,100 locks, forming one series, with master, sub-master, and warders' keys.

'At any time the Governor has the power of stopping out the under-keys; and in case of any surreptitious attempt being made to open a lock, and the detector being thrown, none of the under-keys will regulate it, but the Governor must be made acquainted with the circumstance, as he alone has the power, with his key, to replace the lock in its original state.

'It need scarcely be stated, that Barron's, Bramah's, Chubb's, and most other locks are adapted for all purposes, from the smallest cabinet to the largest prison-doors or strong-room.

'As has been already stated, various and numerous patents have been taken out. Ingenious, however, as are some of the arrangements, they appear to have complicated, rather than simplified, the general construction.

'It is submitted that the true principles of perfect security, strength, simplicity, and durability should be combined in every good lock.

'1st. Perfect security is the principal point to be attended to, as without it no lock can be considered as answering the intended purpose.

'2nd. The works of a lock should, in all cases, possess strength, and be well adapted, especially in the larger

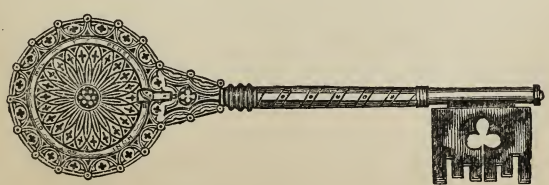
[1] 'Construction of Locks and Keys,' by the late Mr. John Chubb. Read before the Institute of Civil Engineers.

ones, to resist all attempts to force them open ; and both in the larger and the smaller kinds the works should not be susceptible of injury, or derangement, from attempts with picklocks or false keys.

'3rd. Simplicity of action is requisite, so that any person having the key, and being unacquainted with the mechanism of the lock, should not be able to put it out of order.

'4th. The workmanship, materials, and interior arrangement of a lock should be so combined as to ensure the permanent and perfect action of all its parts, and its durability under all ordinary circumstances.'

Besides the better class of locks made in South Staffordshire there are really trumpery locks made in abundance, and Willenhall enjoys an unenviable celebrity for the cheapness and worthlessness of its wares. There is a familiar saying that if a Willenhall locksmith happens to let fall a lock while in the process of manufacture he does not stop to pick it up, as he can make another quicker. The late Mr. G. B. Thorneycroft, who once lived at Willenhall, is said to have been taunted with the fact that some padlocks made there would only lock once, but when told the price of them was twopence each he replied, 'It would be a shame if they did lock twice for that money.' The total weekly production of locks in the whole district was stated in 1866 to be no less than 31,500 dozens. A very large proportion of this enormous supply goes to foreign markets.



CHAPTER II.

THE ART OF BURGLARY.

In order to show the absolute necessity of secure locks and safe depositories for property, especially in banking establishments, it may not be out of place just to trace the systematic care and great sagacity with which large burglaries are planned. An unsuccessful attempt, where the booty is of any magnitude, is seldom made. The first-rate 'cracksmen' always know beforehand where to go, when to go, and what they are going for. When a 'plant,' as it is termed, is made upon a house or a bank, precise information is gained if possible as to the depository of the valuables, and if it is found that the safeguards are so strong in themselves and the locks so invulnerable that there is but little chance of success, the affair is quietly dropped; but if otherwise, then no expenditure of time or misapplied ingenuity is spared to gain the desired end; the house is constantly watched, and the habits of its inmates observed, their ordinary times of going out and coming in being noted. Possibly the confidential servants are bribed or cajoled, and induced to leave the premises when their employers are absent, so that impressions may be taken from the locks, and false keys be made.

When all the keys required are ready, generally one or two men who have not been previously initiated are

called in, and receive their instructions to be ready at a certain hour on the following day to enter the premises. A plan is put into their hands; they are cautioned to step over a certain creaking stair or board, and the false keys of the different doors are given to them. The inmates of the house being absent, their servant takes advantage of this fact to fulfil a long-standing engagement with his or her new and liberal friends; a signal is given; the two confederates enter; the so-called safe is swept of its contents; all the doors in the building are carefully re-locked, and not until the house is opened for business next morning is the robbery discovered.

Many years ago there was a bank robbery at a town in Kent, effected as follows: Two respectable-looking and well-behaved men went to the principal inn of the town and informed the landlord their object was to look out for and purchase a small estate in the neighbourhood. They stopped there for nearly three months, taking frequent drives in their gig, lived well and paid well; and at length took leave one market-day between twelve and one o'clock, much to the regret of the landlord, who felt sorry to lose such unexceptionable customers.

These men were thieves, and at a few moments past one o'clock that very day robbed the bank of nearly £5,000.

The banking-office was the ground-floor of a house in the Market Square, and the manager never left the cash there at night, but always took it to his own residence near by. He was accustomed, however, with the clerk, to be absent from one till two o'clock in the day at his dinner, during which time the money was put into the safe and the premises locked up.

It appeared that all the arrangements of the business were perfectly ascertained and understood by the two sojourners at the hotel, and that the necessary impressions

of the locks had been taken on various nights and the false keys made.

On the day in question the gig was taken just outside the town. One of the men went back, and in mid-day unlocked the street and internal doors, opened the safe, took out the money, and then the two set off to London with their booty and got the notes cashed the same afternoon. After locking the safe the burglars slipped a small ring over the key-pin of the lock, so that when the manager on his return from dinner tried to open it with its proper key, the key would not enter. A smith was sent for, and it was four hours before the safe was opened—too late, of course, for any effective pursuit.

A more recent and notable instance is that of a daring burglary which took place at Mr. Walker's, the well-known jeweller of Cornhill, in 1865, the whole facts of which came to light in consequence of one of the gang volunteering a confession during an action arising out of the robbery. I am indebted to the 'Times' newspaper for the following particulars, which doubtless are still fresh in the memory of some persons: The robbery had been elaborately schemed, and was only accomplished by a regular expedition of well-equipped thieves. The cleverest of the gang had taken Mr. Walker, his family, and his habits under the closest surveillance for seven weeks before, night and day, until at last everything connected with his business and his practice was thoroughly known. This information being complete, a party of five of the robbers repaired to the premises at ten minutes past six on the evening of Saturday, February 4, 1865. The house was let and occupied in floors, Mr. Walker's shop being on the ground-floor, Sir C. Crossley's offices immediately above, and other offices above those, while below the shop was a room tenanted by a tailor. The occupants, when the thieves arrived, had not yet all left for the

night, but the offices on the second floor were empty, and to these three of the robbers at once ascended by means of the common staircase, and there took up their first position, the other two remaining in the street to watch and give signals. At twenty minutes to eight the signal was given by the confederates outside the house that Mr. Walker's foreman, who appears to have been the last on the premises, was gone, and their operations commenced.

It was past midnight before the three robbers inside began their most important work. Mr. Walker's shop was secured by iron doors or partitions, but the thieves directed their attack against the floor, which had not unnaturally been left with less protection. They got into the tailor's room, on the lowest floor, mounted upon his cutting-board and forced their way through the ceiling and flooring to the shop above. Having thus effected a lodgment against the real point of attack, they distributed the duties of the night. Of the two thieves stationed in the street one was to be on the watch, lest Mr. Walker or any of his people should return to the house, while the other was to keep guard over the police and give warning whenever a constable approached. Inside, one of the gang sat upstairs in Sir C. Crossley's arm-chair, at the window of the second floor, to notice the sentries in the street, and the signals of these men he communicated by means of a string to his comrades in the shop.

One of these handed up such instruments as were wanted; the other at length opened the safe (by wedging, as described on p. 36); so that at a quarter to four they washed their hands in the office upstairs, and an hour later were miles away on the Guildford road.

The success in this happily unique case was due to the desertion of the premises for six-and-thirty hours together. The men did not get into the shop till one-and-twenty hours after the commencement of their operations. Aided

by time, the science of the housebreakers was successful. The police passed the place every nine minutes, but with such deeply-laid plans were not likely to detect the mischief going on, and so the thieves escaped for three weeks, when a part of the stolen property was traced and the rascals themselves ultimately captured. Caseley, the reputed leader of the gang, stated that he had had a great deal of experience in opening safes, and there is no doubt he was a clever man; but I believe a part at least of his subsequent statements were exaggerations, likely to be indulged in by a man placed in his position.

Very few cases of the kind, however, show such determination and skill, and thus almost the first robbery in which wedges were used in safe-breaking must rank as one of the most remarkable of our times.

When a large amount of property of either cash, plate, or jewels is deposited in one place, it really is in fact offering a premium to robbers, unless fit receptacles for such property are provided. Notwithstanding the cunning, ingenuity, or violence of the professional burglars, means are at hand by which they may be effectually baffled, and all who are interested in the matter should see that their patent locks or iron safes are really what they ought to be—impervious to fraud and force.

The axiom that 'the best is the cheapest' will hold good with locks and safes, as with most other things. Let it be remembered that first-class work must be done by the best and most skilful workmen, and that to secure them a high rate of wages must be paid.

Most of the house-robberies so common in all large towns are effected through the common street-door latches in ordinary use being opened by false keys. It is a notorious fact that thousands are made year after year, but which do not afford the least security, as they are all so made that any one key will open the whole, and it is

not until the owner has his hall cleared, or his plate carried off, that he finds out that his apparently complex key is a mere sham, there not being in the lock a single tumbler or ward to correspond with the cuts in the web of the key. At a very low computation at least three-fourths of the houses in London can be entered by false keys, and it is simply owing to the vigilance of the often-abused police that robberies are not more constantly effected.

The following particulars, kindly furnished me by Colonel Fraser, of the City Police, will show what facilities are placed within the reach of burglars by careless householders.

Return of Premises found open, or otherwise insecure, by the Police in the City of London.

Year	Number
1871	2,656
1872	2,452
1873	2,957
Total	8,065

By using secure locks or latches on all the outer doors of houses an immense amount of work would be saved to the police, and it is really a question for ratepayers to decide if common and insecure locks should be allowed to be used any longer.

While on the subject of house-robberies I may refer to other modes of entering dwellings, with which the public ought to be acquainted in order to be on their guard.

Admission to a house by the connivance of a dishonest servant is, of course, sometimes obtained by thieves, and the only way of preventing this is to be careful whom one employs in the house. But, if possible, the thief will get into the house unaided by a confederate, who after all might foil his plans, and in any event will claim a part of

the plunder. So the house must be carefully watched, and, if possible, examined, in order to discover the easiest mode of access.

Frequently some coal-cellar window is found to be left conveniently unbarred, although all other windows and doors are barred and bolted; or perhaps all the windows have safety-fasteners but one, as was the case in a residence near London, a short time ago, when the burglars *happened* (so it was said) to pitch upon the unprotected window, and entering cleared the room of valuable jewellery.

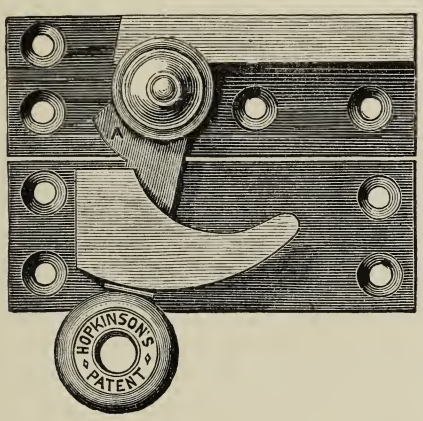
Beggars or hawkers are often in the pay of thieves, endeavouring to get information—that may not be used perhaps for a long time hence—and such visitors should certainly never be allowed inside one's house, though their visits are too often encouraged by the weakness of the domestics.

Now, it will be asked, what are the remedies best adapted to prevent robbery in these various ways? Firstly, be careful to have trustworthy servants, or all other precautions are unavailing. Secondly, have plate-glass to all windows in the house, for this cannot be broken, as common sheet-glass can, without noise. Thirdly, as shutters are really no protection at all, and frequently are not fastened at night, let all windows and openings that can be reached easily from the ground have strong bars built into the stone or brickwork, not more than five inches apart, where this can be done without disfigurement; and let the windows on every upper floor have either Hopkinson's or Dawes's patent window fasteners, which cannot be opened from the outside, and are simple and strong in construction and cheap in price.

The engraving shows Hopkinson's fastener, an extremely simple and ingenious invention. The projection on the left side, as the fastener is moved, comes over the opening

and wedges fast any instrument introduced from the outside for the purpose of forcing back the catch.

Fourthly, keep a dog, however small, *inside* the house; this is a wonderful safeguard, and extremely disliked by burglars. Fifthly, have any number of bells on shutters, electric wires, or other gimcracks that you please, and place no reliance on any of them. Lastly, leave as little property as possible, certainly no silver plate or jewellery, lying about, so that if a thief should overcome all obstacles to entrance, he may not find much ready to hand.



The sort of robbery I have alluded to is committed either at night or in the dusk of the evening or at the dinner-hour, when the inmates are all in one part of the house. There is also that very frequent and too often successful plan of stealing coats, &c. from a hall, when some stranger calls with a fictitious message that causes the servant to leave him alone for a moment, during which he hurries off with everything within reach that is worth stealing. To prevent such an occurrence plainly the best thing is never to allow a stranger to wait inside one's door.

A professional burglar's tools comprise skeleton-keys, silent matches, a dark lantern, a wax taper, a palette-knife used for opening windows by pushing the fastening back; a small crowbar, generally made in two pieces to screw together, and with one end forked; a centre-bit, and a carpet-bag. If the object of attack is a safe, then to these must be added chisels and steel wedges of different sizes, an 'alderman,' or large crowbar, a 'Jack-in-the-box,' some aqua fortis, and sometimes gunpowder for blowing open locks. Besides providing himself with tools, the burglar will often wear a 'reversible,' or a coat which can be worn inside out, each side being a different colour, so that if he happened to be noticed he will turn his coat in some quiet corner and become another man to all outward appearances.

The writer of an able article in the *Cornhill Magazine* of January 1863 gives as a list of the various ways in which houses are regularly broken into, the following: 'Jumping a crib,' which is entrance by a window; 'breaking a crib,' forcing a back door; 'grating a crib,' through cellar gratings; 'garreting a crib,' through the roof. Entrance in this last way, the writer states, is sometimes cleverly effected (from the leads of an empty house adjacent) by means of an umbrella. First, a few slates are removed, then a small hole is made, and through this aperture a strong springless umbrella is thrust and shaken open. Again the thieves go to work upon the hole in the roof, which they widen rapidly and with perfect confidence, since the *débris* falls noiselessly into the umbrella hanging beneath. When in the house the thieves' only care is to move silently and to show little or no light. When the plunder is secured and the confederates signal that the way is clear, the burden is divided, and they at once separate, though perhaps going to the same place. Cabs are occasionally employed by the thieves; and though the drivers

are not exactly in league, yet they must know pretty well by whom they are being hired. The plunder is disposed of immediately to 'receivers,' who always drive a good bargain, and if there is any plate or gold at once put it into the melting-pot. These receivers are the curse of large towns, where alone they are to be found. It is entirely owing to them that the majority of robberies are committed, for if thieves had to run a second risk in disposing of the goods after stealing them, they would not continue a dishonest life with the chances of success they now have. The police are generally well aware of the men who thus assist the thieves, but the difficulty of getting evidence against them is extreme, although occasionally a rascal is caught and severely punished owing to information being received from some informer. There are no less than eighty-seven houses in London *known* to be those of receivers of stolen goods.

In February 1858 there were in Manchester alone ninety-four returned transports, and out of the whole of that number there were not more than six in employment or who had any known means of livelihood. In view of this statement can it be wondered at that in the eleven years from 1857 to 1867 there were no less than seventeen successful robberies effected in that city alone, involving a loss of property amounting to £25,788, chiefly in cash and jewellery? This loss would have been largely augmented had it not been for the vigilance of the Manchester police, who could not, however, possibly frustrate every attempt made by dishonest men let loose upon society in large numbers by a system which is open to very serious objections. The Habitual Criminals Act proves that the country has at length recognised the fact that the ticket-of-leave system has been grossly abused by convicted persons, and that to protect life and property effectually it is necessary to give the police more power of supervision

over suspected characters. For the benefit of those not acquainted with this Act, I may state that its most important provision is to give a Judge power to include in the sentence of a person, who has been previously convicted, a certain term of police supervision, to take effect after release from prison; and during this term the person may be called upon at any time to prove that he or she is gaining an honest livelihood—the burden of the proof resting with the suspected person, instead of the police being required to prove dishonesty.

A man who commits a great robbery is not one who up to that moment was honest and industrious; it is most probable that he has been an associate of thieves, and has been apprenticed to it, so to speak, as to a trade; hence the advantage of the new system by which he can be watched and if necessary captured on suspicion. The London police have now on their register 117,000 names of habitual criminals, and the list is said to be increasing at the rate of 30,000 a year.

A few somewhat imperfect statistics may be given. In London, during the years 1862 to 1867 inclusive, there were eight successful burglaries, in which £14,845 worth of valuables was stolen; in other large towns of the kingdom, such as Glasgow, Sheffield, &c., there were thirteen burglaries, with a loss of £11,375; and if our Colonies were to be taken into account, at Hong Kong alone there was a robbery (referred to more fully on page 59), in 1865, of £50,000 from a bank.

Omitting this last, however, it will be seen that in eleven years no less than £52,000 of property was stolen by burglars in Great Britain. It is true a great deal of this was recovered—sometimes in remarkable ways, an instance of which was the finding of some gold watches in the Thames, stolen from Mr. Walker's, Cornhill; one of the watches having attracted the attention of a river police-

man. But, on the other hand, there were numbers of successful attempts where no booty was found; a large number of unsuccessful attempts; and many of both kinds which never appeared in the newspapers at all.

The total would indeed make a formidable list, and yet there is hardly a case in which proper care combined with the use of the best safeguards would not have prevented all loss.

In the year 1873 the total amount of property lost *by robberies of all kinds* within the metropolitan district alone was £84,000, of which nearly £21,000 was subsequently recovered.

So large a proportion of this loss was occasioned by the use of insecure fastenings on doors or windows, that the Metropolitan Police have drawn the special attention of householders to the risks thus incurred. Colonel Henderson not long since issued a notice, of which the following is an extract :—

'Caution to Householders and others.—The Commissioner considers it to be his duty to caution householders and others that larcenies are in most instances committed by thieves entering through windows left open or so insecurely fastened that they can be readily opened by thrusting back the catch from the outside with a knife, without any violence or force whatever. The plates of window-fastenings should overlap each other, and self-acting side-stops should be used in sashes. Attention is also directed to the following means by which thieves effect their purpose :—

'In the absence of the family, especially on Saturday and Sunday evenings, entering with false or skeleton keys, passing through an empty house in the neighbourhood, going along the parapet, and entering any window found open—climbing up the portico and entering through upper windows—calling at houses under pretence of

having messages or parcels to deliver, and during the absence of the servant stealing articles from the hall or passage and decamping.

'If ordinary and necessary precautions were taken, as above recommended, the efforts of the police in preventing crime would be materially aided, and property more effectually secured.'

A short time since there was a robbery at the warehouse of a person who immediately wrote to the newspapers blaming the police and making out a plausible case. Now, the real facts were, that this person gave up residing on his City premises without informing the police. The door had on it only a common latch, easily opened by a false key. There was a window up a side-passage through which it was easy to obtain entrance; and though all these circumstances conspired to facilitate the operations of thieves, yet this was thought a proper opportunity to blame the City Police!

Although seventeen years have elapsed since the conviction of the men who stole the bullion on the South-Eastern Railway, the case is still the most remarkable of its kind—remarkable for the deliberation, the professional spirit, and the pecuniary resources of the modern offender.

The following very condensed account I take from the 'Times' newspaper of the day, merely premising that the case shows the extreme importance of guarding one's keys most jealously, for even up to the present time no lock, such as can be brought within the reach of everyone for practical use, has been invented that will permit of its keys being carelessly used.

On the night of May 15, 1855, gold to the value of £12,000 was taken from the van of a train on the South-Eastern Railway, between London and Folkestone. The boxes were weighed in London and again at Boulogne; at the second place the weight, as was subsequently dis-

covered, differed from the weight in London. The weight in Paris corresponded with the weight at Boulogne. Consequently the boxes must have been tampered with between London and Boulogne, or, as it had been impossible to touch them while in the boat, between London and Folkestone. When the boxes were opened, bags of shot were found substituted for gold. Of course the surprise was great, and the search after the offender earnest. But whatever may be the skill of the detectives, we know from sad experience that the criminal world is more than equal to them in craft. For sixteen months the pursuit was in vain, and the robbery was well-nigh forgotten, when an unexpected revelation threw light on the matter. A man named Edward Agar was convicted in October 1855 of uttering a forged cheque, and sentenced to be transported for life. This man, after his conviction, stated to the authorities that he could give information respecting the great gold robbery of 1855. On being questioned he announced himself as one of the perpetrators, and named as his accomplices Pierce, formerly in the service of the South-Eastern Company; Burgess, a guard; and Tester, a clerk in the traffic department.

Agar was forty-one years of age, and had by his own confession lived by crime from fourteen to twenty years. His evidence was that Pierce first suggested the scheme, but that he himself thought it impracticable. Pierce said he believed he could obtain impressions of keys of the Chubb's locks by which the iron safes were secured; and Agar then answered that if it could be done he thought the thing might be effected. Pierce and Agar went down to Folkestone as casual visitors for the benefit of sea-bathing. They took lodgings and employed themselves in observing the arrival of the tidal service trains to the boats. This was in May 1854, twelve months

before the actual commission of the robbery—so long a time can modern depredators afford to spend upon their preparations. They went daily to the pier to enjoy the fresh air ; but their constant observation of the trains and the station aroused suspicion, and they left, though not before they had discovered 'what Chapman, who had the key of the iron safe, did when the trains arrived and the luggage was removed to the boats.' By these means it was ascertained where the key was kept, the impression of which it was desirable to obtain.

But to know where the key was kept and to obtain possession of it were very different things, and Agar, according to his own story, was much disheartened. Not so Pierce. Pierce knew a man named Tester who was in the office of the Superintendent of Traffic, and Tester could get possession of the keys for them. However, time rolls on, and we are in August, when Pierce discovers that the locks are to be altered, and that the new keys will be in Tester's hands. Tester was the clerk who corresponded with Mr. Chubb on the subject of the alterations, and by his means the impression of a key which opened one lock of each box was obtained.

But as each box had two locks it was necessary to obtain the impression of another key, and the following device was adopted: Agar was in possession of no less a sum than £3,000. It was arranged that a box of bullion of the value of two hundred pounds should be conveyed in the iron safe in the usual way, and that it should be delivered to him under the name of Archer.

Agar goes for the box, and it is delivered to him by Chapman, who opens the safe with a key which he takes from a cupboard. Thus Agar learns where the second key is kept. Now, how are they to obtain an impression of the key? Two months have elapsed since they got the impression of key No. 1. This is October,

and they are still without No. 2. But they are not disheartened. Pierce and Agar go to Dover, and put up at the 'Dover Castle;' they walk over to Folkestone, and arrive just when the train is coming in. In the confusion of an arrival the attendants leave the office for a few minutes. Pierce goes boldly in, opens the cupboard which contains the key of the iron safe, hands it to Agar, who takes an impression, and then replaces it. Thus five months after their reconnoissance at Folkestone they have surmounted the first difficulty which suggested itself to the reflective mind of Agar. They have obtained wax impressions of the keys; everything else remains to be done.

The next thing, of course, was to make keys from the impressions. For that purpose lodgings are taken in Lambeth and Kennington. Pierce disguises himself in a black wig, and the next two months are spent in filing keys. When the keys were completed to a probable similarity with the rough wax impressions—no easy task, it would seem, for two inexpert operators with common files—it was necessary to try them. Agar went down several times in the van with Burgess, the guard. They did not fit at first, but they fitted more nearly every time he went. At last they fitted completely, and the deed was resolved on. Of course, after nearly a year's labour, it was not worth their while to fly at any paltry game—they would wait till a large sum was to be sent. Two chests would hold about £12,000, and they heard that £12,000 was shortly to be sent.

They then buy shot to replace the gold. Agar and Pierce are admitted into the van by Burgess, and on May 15, 1855, twelve months after the deed was planned, the boxes of Messrs. Spielman, Bult, and Abell are securely rifled. Nineteen months after the crime was committed, and more than two years and a half after it

was planned, justice overtook the delinquents. No sentence was passed upon the informer Agar, who was remitted back to prison under the sentence he had incurred by an act of forgery; but Burgess and Tester were sentenced to transportation for fourteen years, while Pierce, through a technicality, got off with only two years' imprisonment: and so ends this romantic case.

One of the convicts, I have heard, has been of some use to the police, for, like many other convicted thieves, he has been communicative, and at least one improvement in lock-making has resulted from this man's suggestions.

Though a robbery so patiently planned, so quietly carried out, and with such a successful result, is rare; yet we still hear of instances wherein the same forethought and misguided talent are shown.

The dark autumn and winter evenings have latterly been chosen for the commission of what are earning a separate name, so numerous have they become—'Jewel Robberies.' At the West End of London and the fashionable suburbs there have been numerous cases in which the thieves wait till the inhabitants are assembled at dinner—having possibly left some of their jewellery lying about on dressing-tables—and by entering through a window the burglars are able to make a successful haul. Either in this manner or by an ordinary night burglary much of the plate and jewellery is stolen with comparatively slight risk of discovery. The residences of Sir F. Peel, the Dowager Marchioness of Cholmondeley, the Countess Waldegrave, the Countess of Donoughmore, and many other noticeable personages have recently suffered from these unwelcome visits.

The following notice, issued some time ago, I have Colonel Fraser's permission to republish. It very clearly shows the responsibilities resting with both the police and

the public of large towns. If householders would but perform their part as well as the police do in this matter, robbery of the kind indicated would be of the rarest occurrence :—

POLICE NOTICE.

Recent occurrences having shown that an impression somewhat extensively prevails in the City that the duty of protecting house property at night is one which belongs exclusively to the police, it is desirable to point out what the true functions of the police are with respect to the guardianship of house property, inasmuch as the proprietors of houses, when distinctly informed as to the nature and extent of the protection which they may reasonably expect to receive from the police force, will be in a better position to determine what those additional safeguards should be which ordinary prudence makes it incumbent on them to provide for themselves.

Under the influence of the impression above referred to a practice has sprung up in the City, and is gradually increasing, of leaving shops and warehouses, stored with goods of great value, entirely untenanted at night, and throughout the whole of Sunday. Numerous buildings are let out in separate rooms to separate tenants, who require them only for purposes of business during the day; the street-door, during business hours, is left open, in order to give ready access to every part of the house; and thus, in the case of houses which are habitually deserted at night, not only have thieves great facilities for entering them, and secreting themselves there by day, but they may do this with the knowledge that they will, almost certainly, be left for many hours at night in the undisturbed possession of the abandoned premises.

These risks are, moreover, greatly aggravated by want of due care in thoroughly searching the house before it is finally closed for the night, by the defective condition, in many instances, of the external fastenings, and by neglect in making even these fastenings secure.

It has, indeed, been supposed by some persons that if, during their absence, they leave lights burning in their shops, and openings in the shutters through which the interior of the shop can be partially inspected, the property within may be safely left to the exclusive guardianship of the police. This practice has never been approved by the head of the force, and is itself open to serious objection, as tending to encourage reliance on a contrivance which is not only untrustworthy, but which may be used by dexterous thieves to further their own plans.

Nor must it be imagined that a policeman who is in charge of a beat can, without manifest neglect of his duty to the householders generally, devote to the shops where the practice in question is followed, the special supervision which seems to be expected from him. If a constable on duty were bound, each time he passed, to make a careful inspection of the interior of shops through the several apertures which individual shopkeepers may please to make in their shutters, he would obviously be unable to complete the circuit of the buildings under his charge within the time appointed for that purpose, and the majority of houses on the beat, as well as passengers in the streets, would be left without that protection which the police should properly afford.

Under these circumstances it is most important to bear in mind that the special watching over particular premises, which it is sought by the adoption of the custom referred to to exact from the police, is a duty which the police cannot undertake to perform.

The chief functions of police in connection with the protection of house property at night are to prevent, as far as possible, a forcible entry being made into any building from without; to afford protection to all houses *equally*; to be vigilant in detecting the first indications of fire, and to exercise a general supervision throughout the night over the doors, shutters, and other external defences of the houses.

These functions the police can discharge, but they cannot be responsible for what may be occurring out of their sight, within deserted buildings to which they have no access—they

cannot keep stationary guard over the doors of unoccupied warehouses unprovided with any locks or outer fastenings but such as are of the most worthless description—they cannot prevent robberies being effected in premises to which thieves are admitted during the day and secured from all interruption when locked in for the night by the owners of the premises themselves—nor can they, in justice to the legitimate claims which the majority of the ratepayers have on the protection of the police, employ the greater portion of their time in watching over the property of a few individuals, who invite attacks from thieves by omitting to take the precautions which common prudence enjoins.

James Fraser, Colonel,
Commissioner of Police.

City Police Office, 1865.

CHAPTER III.

SAFES AGAINST THIEVES.

Of late years there has been an increasing demand for strong safes, and it is in response to this demand that such a multitude of patents have been taken out. Of these very few have been introduced to the public, for most of the inventions are by persons not practically acquainted with the trade, who consequently have not the opportunity of foreseeing the practical difficulties in the working of their patent, nor often the means of introducing it to public notice.

Perhaps one patent in six is ultimately used, but even of these many are but unwitting copies of former ones. As an instance, a special mode of making an angle-iron frame is claimed by three inventors. However, after the great robbery at a jeweller's in Cornhill, in 1865, among the numerous patents introduced there were some of undoubted advantage, the object in all being to give greater strength to the door and its fastenings, and (in some patents) to close all joints in a safe against the operation of wedging.

The employment of wedges for forcing open safes was then quite novel, and therefore the many improvements suggested or patented were intended chiefly to baffle this new mode of attack. It is necessary to notice very briefly the salient points of the best of those inventions which by being now used have proved to some extent their utility. Perhaps the safes most generally

known are Milner's, Tann's, Hobbs's, Chatwood's and Chubb's. There are many other makers, most of whose names appear in the list of patentees, but whose productions have hardly obtained the notoriety belonging to the five names here mentioned. Respecting the first-named makers, so many different qualities are made that it is difficult to give any definite opinion of their work, but it may be safely said that the makers rely more upon the general construction of their safes than upon any special invention to overcome the 'wedge' or other instrument. They use to a large extent wedge-shaped pieces of iron fastened to the inner face of the door, which fit into, as the door shuts, corresponding holes in the frame or lining face. These cannot, however, be used well at the back of the door, in consequence of the clearance required when it is swinging open; otherwise, if fastened in a solid manner, they give some additional strength. One of the noticeable features of Messrs. Milners' safe is the use of an outside band or frame round the body, the advisability of which position for it is sometimes questioned, although it adds somewhat to the appearance of strength. They also use hinges in place of the pivot or centre working in a socket, the more general mode of construction.

One of their stronger safes has been described as follows: 'Its dimensions being $83\frac{1}{4}$ inches high; $58\frac{1}{4}$ inches wide, and $36\frac{1}{2}$ inches deep, and secured by one single and two pairs of double doors. The first, which is of massive strength, and well provided with lock, bolts, and wedge-guards, secures a small chest or treasury designed for bullion, which is in fact the principal object for which the safe was intended. Over this door close a pair of equally strong double doors, each shooting eight massive bolts, and coated, like the inner door, with a layer of hardened steel. Over these second doors close a third pair, consisting, like the inner ones, of two $\frac{1}{2}$-inch plates of iron separated by a

plate of $\frac{1}{2}$-inch cast steel. The composition is $3\frac{1}{2}$ inches thick. The weight of the safe is thirteen tons (?), and the cost £300.'

The safes made by Messrs. Tann, of Newgate Street, make no pretension to any special novelty beyond having, in the strong qualities, a projecting rim *all round* the inside of the door, which fits into a corresponding recess, in order to foil the action of wedges. The finish of most of these safes is decidedly good, showing careful workmanship.

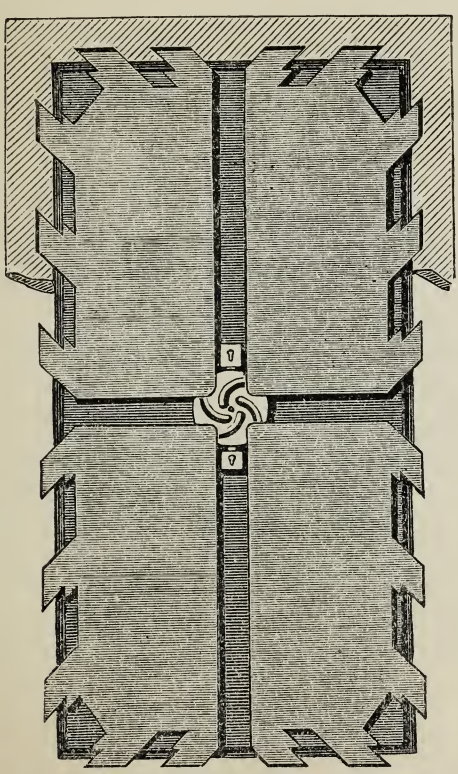
The following is a published description of one of Messrs. Tann's safes: 'No special provision as against fire was made, strength being the first object. The size of the safe is 5 feet 6 inches high, and 2 feet 4 inches deep, about four tons weight of iron being used in its manufacture. The case consists first of boiler plate of $\frac{1}{2}$-inch, then of $\frac{3}{8}$-inch plate of steel and iron welded together, a third outer case being of $\frac{3}{8}$-inch iron plate. The frame is six inches by $1\frac{1}{4}$ inches, with solid corners; and the construction of the doors is novel. They are folding, and fit into each other at their meeting with dovetails seven inches high and one inch wide of solid $\frac{1}{2}$-inch iron, which effectually prevents any attempt to force them apart by wedging. The back edge of each door is provided with what is technically called a hook rebate, with the same view.'

Messrs. Hobbs's safes are also of various qualities, their strongest having bolts of a hooked or claw shape, and the outer edges of the body plates being protected in a peculiar way by a covering under which molten metal is run to cover or close the joints.

The safe made by Chatwood has a door with a curved edge,[1] and bolts of hooked shape which slide behind projections on the frame; sometimes he uses also projecting pieces on the inner edge of a door, somewhat in Milner's way, and his stronger safes have hard metal run in while hot between

[1] A curved edge had been previously patented by Shore, February 22nd, 1865.

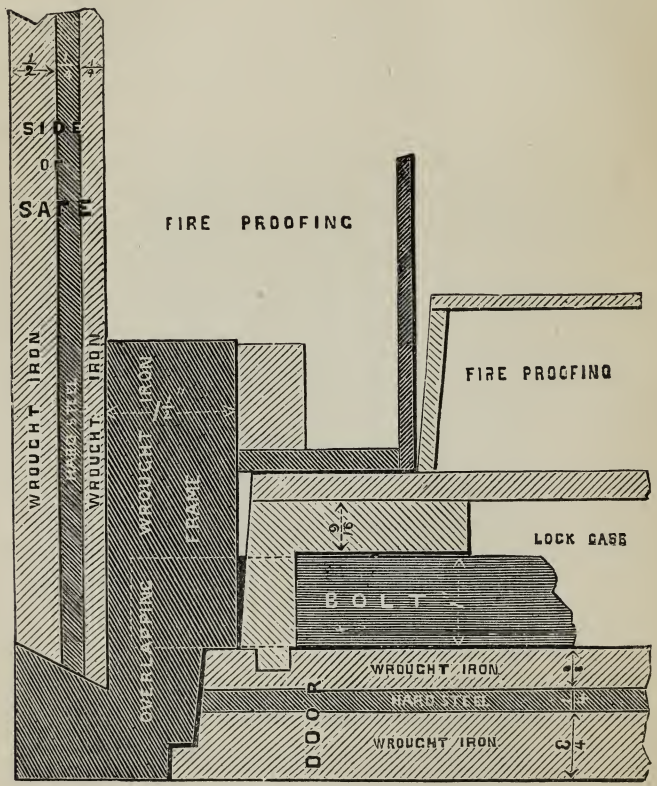
two iron plates to form the sides. Some of his safes are very ponderous, and more work is spent on them than seems necessary for any but the most extraordinary requirement. The finish is good, and the general plan of construction more elaborate than that used by some makers. The number of applications for patents made by Mr. Chatwood will be seen by reference to the list to be large, but only some of them or parts are in use.



ELEVATION SHEWING DIAGONAL ACTION OF BOLTS

Messrs. Chubb and Son's safes are chiefly in two distinct qualities, the best being made as shown by the annexed

engravings. The advantage of the diagonal bolts wil be obvious; they fasten into a solid frame, which in its turn overlaps the body-plates, so that if it were possible to get a wedge past the rebate on the door, the moment the

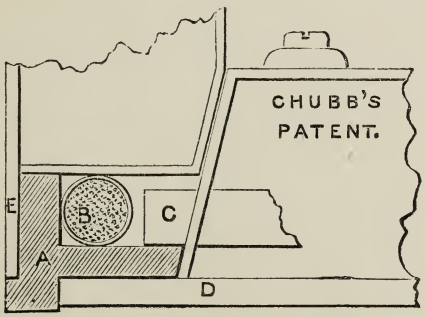


SECTION OF FRONT CORNER

wedge was inserted the bolts would grip the sides and bind it tightly. The edges are joined by angle-iron, rivets and screws, and are rebated and dovetailed together.

Messrs. Chubb and Son have lately (1874) patented a new mode of construction, with the object of providing a

stronger safe at a less cost than has hitherto been charged. The frame of the safe, on which the door hangs, is a solid T-iron, its outer edge overlapping the body-plates, and the flange receiving behind it the bolts. Though the inner lining has no screw or rivet, yet it is most securely fastened in the process of joining the other parts. In order to increase the fire-resisting properties of this new safe, besides the usual casing of fire-resisting material, a tube is introduced into the open space behind the T-iron, filled with a substance that will on the approach of fire cause steam to be projected into the interior of the safe. The engraving shows a section of one corner of this patent safe, and an elevation of it will be found facing page 36.



Beyond the fact that its simplicity of construction enables it to be produced at a moderate cost, the chief advantages claimed for this particular safe are:—

1. The door being slightly recessed when shut, a wedge cannot be inserted with the same ease as if it were flush; and if it is inserted, the pressure is exerted against the point of greatest strength and away from the door.

2. The frame being a special T iron section with a thickened corner, its strength is enormous, and the power necessary to bend it can hardly be applied but by machinery.

3. The bolts fasten behind this solid iron, in place of, as is usually the case, into the lining.

4. The edges of the outer plates are recessed into the frame, so that there is not an open joint.

5. The outer plates are fastened to the frame by a new screw rivet, which can neither be driven in nor taken out.

6. Even if one of the plates should be taken off, the lining cannot be got out, in consequence of the mode adopted for securing it at the front.

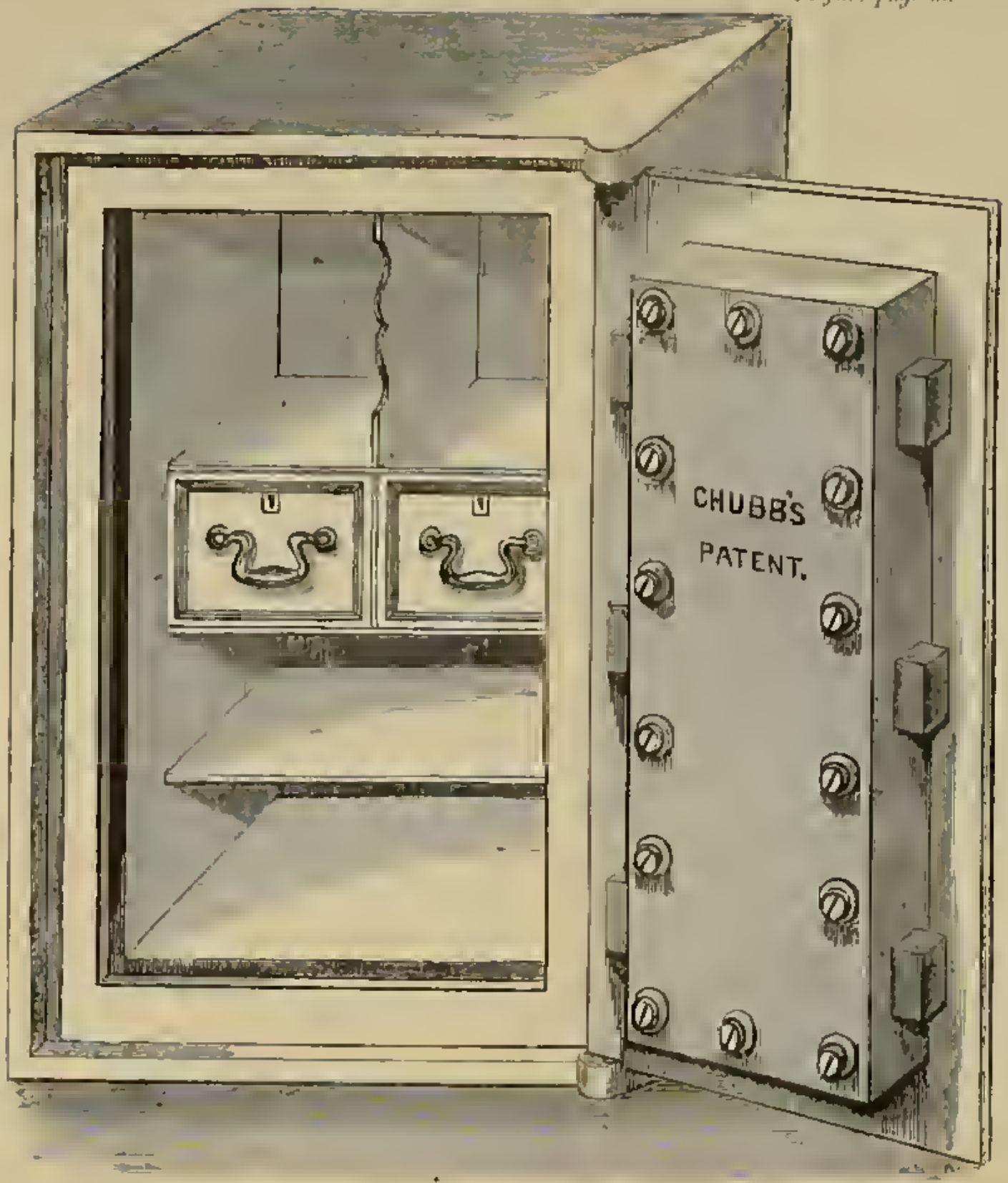
7. The adoption of the Patent Steam Tube adds greatly to the fireproof qualities of the safe at the part most subject to the entrance of heat.

Among safe manufacturers I may name Messrs. Mordan and Co., Mr. Whitfield, Mr. Elwell, Messrs. Perry and Co., Mr. Price, and others, whose productions I have not space to describe.

There are in Staffordshire certain firms who make safes of the lightest and most trumpery description, chiefly for export. A partner in one of these establishments once told me that as long as the safes were strong enough to stand the rough voyage round the Cape to India they were all that was needed! I need hardly say that a safe need be no stronger than a packing-case to stand *that* test. There are, however, already signs of a much better article being required in the East; and the export trade in good English safes to India, China, Australia, and other parts is rapidly becoming of much importance.

Wedging has already been mentioned as an ingenious and somewhat new mode adopted by burglars to force open safes. It is accomplished by means of a number of steel wedges, thin and small, and about two inches long by half an inch broad; these are driven in one by one at different parts round the edge of the door; gradually

To face page 36



CHUBB'S NEW PATENT SAFE, WITH T-IRON FRAME.

thicker ones are put in until the side has been sprung away sufficiently to allow a crowbar to be inserted, and then if the bolts are not of the very best the door is likely to be wrenched open. The sound of hammering the wedges is deadened by a leather pad being put under the hammer, so that it becomes almost a silent operation.

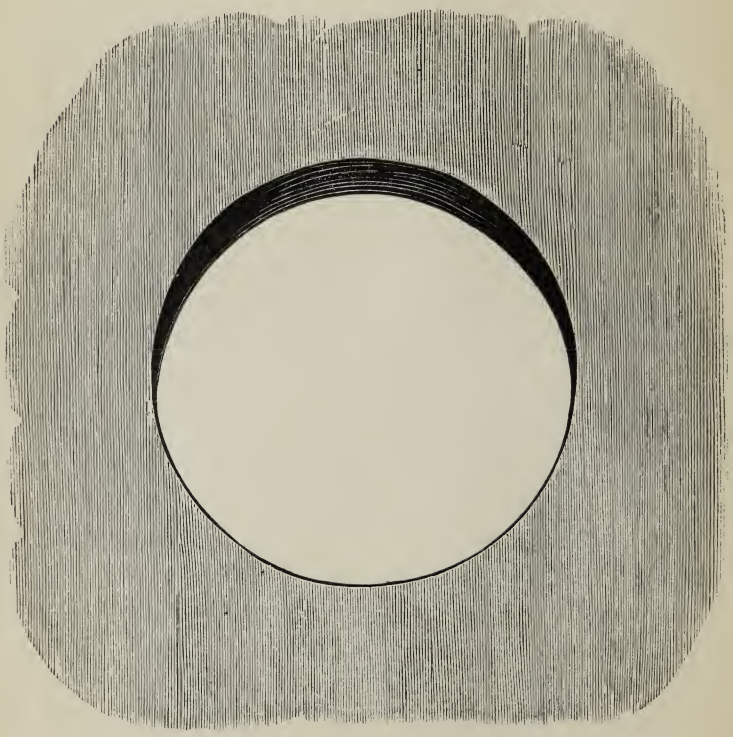
A convicted burglar, who had enjoyed the advantage of some experience in wedging safes, stated that on first trying the door of a safe, if the wedge sprang out and would not remain in the joint without being held, it was generally hopeless to proceed with wedges; but if the first wedge took 'a bite' in the joint and stayed in, he was almost certain of success.

But besides this method there is that of using drills, a very favourite way formerly with thieves, and one that has lately again become popular, because of the increased facilities for procuring better drilling instruments. The object sought in drilling is to get at the lock or working parts, so that by destroying the works and bolt of the lock the handle of the safe merely has to be turned and the door comes open. It is quite easy to drill any number of holes into an ordinary *iron* safe, but unless the holes are near the lock the contents of the safe cannot be reached without much labour and time. Therefore to counteract the drilling it is necessary to protect the lock by steel or some other hard substance. A plate of steel well fixed is usually employed, but in addition to this Mr. John Chubb invented a very simple but effective mode of protection. A number of small holes are made in the door-plate from the inside almost through the plate; the holes are tapped, and then filled up with hard steel screws; so that when a drill touches, however slightly, even one of the steel screws, its edge immediately breaks and the drill becomes useless.

The construction and operation of the powerful instru-

ment which made large holes was unknown until one of them, with all its tools, was captured by the police, and a more powerful, well-made, and compact instrument has seldom been seen. By the courtesy of the Metropolitan Police Authorities Mr. Chubb was allowed to experiment

Fig. 1.



with the instrument, and his attention was directed to provide some means to baffle and destroy its operation. This has been effectually done, and the improvement secured by letters patent.

It would be obviously improper to publish any description or illustration of the machine itself, but fig. 1

shows a part of an iron door with a hole two inches in diameter cut through it. Fig 2 is the cutting tool used,

Fig. 2.

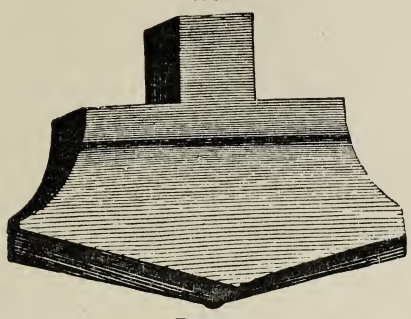
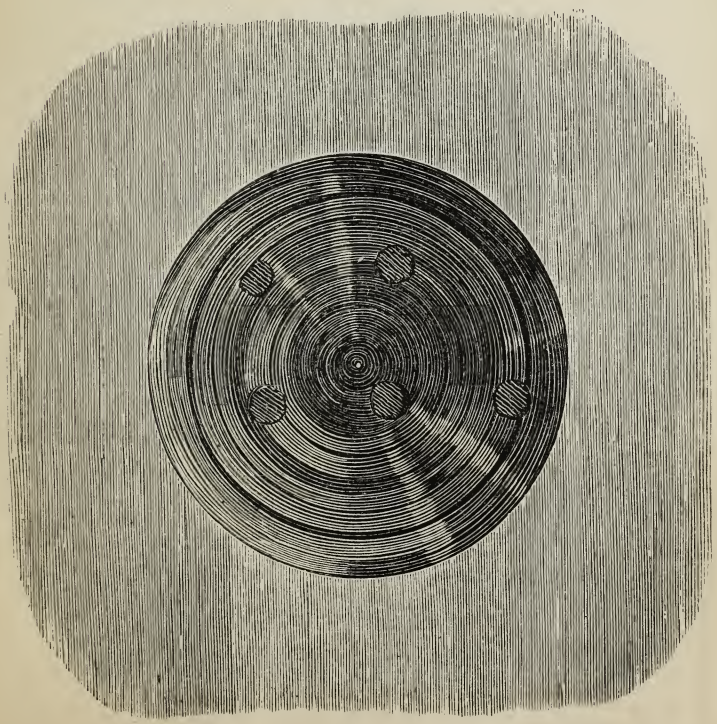


Fig. 3.



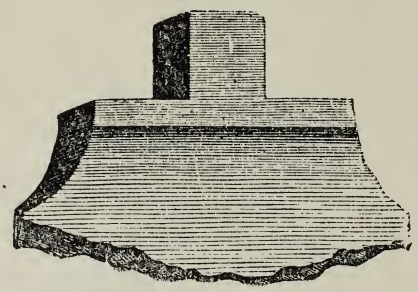
and uninjured, as it was when taken from the machine after cutting the hole. Fig. 3 also shows a part of an iron

door, having the patent improvement, upon which a trial was next made by the instrument *with the same cutter.* No impression, farther than taking a mere skin off the surface, could be made, and the cutter was utterly destroyed, as shown in fig. 4.

Another and more powerful machine was taken by the Manchester police, with cutters capable of making much larger holes, but the improvement is equally effective in destroying the tools.

A third and more desperate mode of opening safes is by

Fig. 4



introducing gunpowder into the locks, destroying them, and thus opening the door with ease. This, however, has not lately been tried to any extent; the noise made is likely to lead to detection. It is rather a dangerous thing to try, and the locks of good safes have generally received such improvements as enable them to resist the shock of an explosion without injury.

There have been other methods said to be used by burglars to obtain their object, such as softening steel with a blow-pipe, so as to get a drill through it, or using drills made of diamonds, which are said to be very powerful, or employing acids to act upon and destroy hard steel, but I have not known of any burglaries proving successful by these means.

There is no doubt a vast amount of low ingenuity and cunning always at work, quietly scheming or planning the best mode of getting at the treasure so often kept in safes, and the only safeguard against this is to get the best safe possible, and then not to rely upon its being utterly impregnable (for no safe can be that), but to use ordinary watchfulness and care, so that it may not be exposed to unusual risks.

A safe is protected as much by having careful and honest persons in the employ of a firm as by its own strength; and the common-sense view of the matter to take is to advise all who wish to obtain the best security to pay what is necessarily a good price for a good safe, and to take good care of it—and its keys.

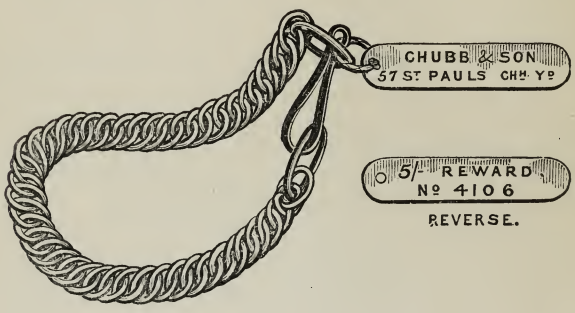
The careless way in which the keys, not only of safes, but of warehouse doors, private boxes, and bags are left about, has been the cause of many robberies.

The great gold robbery on the South-Eastern Railway in 1855 was effected through the thieves obtaining, though only for a few moments, possession of the keys and taking an impression from them. A jewel robbery at the West End of London in 1872 was owing to the key of the jewel-case being left in the same room as the case. It is often found that important keys instead of being in personal custody are kept in some drawer or box having only a very common lock.

Even bankers, careful as they are, need a caution about this, for their keys are so numerous in most instances that great care should be exercised to prevent them from ever getting into improper hands; whatever kind of keys are used, they should never be out of the possession of their rightful owners.

A plan, to which I may call attention, because of its complete success and simplicity, has been extensively used for the recovery of lost keys. It consists of a chain with

a label attached to it, engraved as shown in the accompanying illustration, the object being to ensure the return of the keys without the finder becoming aware to whom they belong, thus preventing their possible unlawful use. The bunch of keys being brought to the address on the label, by reference to a register kept of each label, the



rightful owner is known and communicated with. Several thousands are now in use, and their value is proved by the constant, almost daily, recovery of keys.

Some of the instances in which this plan has been successfully used are somewhat remarkable, and among these may be mentioned the loss of a gentleman's keys on one of the Swiss mountains. All hope of finding them was given up and a fresh set accordingly made; but the following year a bunch of keys was found where the snow had melted, and these, brought home by an English traveller, were found to be the missing ones.

Perhaps a more curious case, in which an unexpected use was made of the register, occurred at the time of the terrible Abergele accident to the Irish mail train. Mr. Lund, a passenger in the train, was killed, but nothing could at first be found upon him as a likely means of identification. He happened, however, to have a registered chain, and upon telegraphing to my firm the number on the label his name and address were at once discovered.

It may be of use to add a few particulars respecting the amount of coin that can be stowed in a certain space, in order that it may be easily calculated how much any safe will hold. The Bank of England reckoning for the room required to stow away gold coin in bags is 79 cubic inches to 1,000*l.* One cubic foot will contain no less than 21,875*l.* In order to allow a slight margin and to be on the right side, it may be considered that 80 cubic inches will contain 1,000*l.* in bags of sovereigns.

For silver coin the Bank reckoning is that 157 cubic inches will hold 100*l.*, and that one cubic foot will hold 1,235*l.* in bags. To allow a margin as before, it may be said that 160 cubic inches contain 100*l.* in silver coin.

CHAPTER IV.

SAFES AGAINST FIRE.

Perhaps there is a greater demand for fire-resisting than for thief-resisting safes, and certainly it is in the former character that they are most often put to the test. The consideration, therefore, of what is the best form of construction to cope with fire is most important; while it is also a much simpler matter than when strength against thieves is required.

In fire we have an element whose character is known, and which cannot attack us in some new way for which we are not fully prepared. All that it can do to a safe is to exercise upon it a certain heat, the intensity of which may be pretty nearly determined, and which cannot in actual practice last beyond a certain time. Probably heat that will melt iron in a large mass is seldom produced in the burning of an ordinary dwelling-house; but in a warehouse with inflammable contents such fierce heat often exists, so that a safe should be proof against it for two or three hours. Unless a safe were very bulky it could not well preserve its contents without any damage for a much longer time; and indeed it is not necessary, for no safe is very likely to be exposed to an intense all-round fire longer than three hours; by that time it will either have fallen into rubbish, or the *débris* from above will have covered it in, and protected it from immediate contact with the fire. It will be seen from this that it is ad-

visable not to build a safe partially into a wall or recess; the chances being that it will be kept in its place long enough to have the full force of the fire expended upon its exposed portion, and then fall a greater distance and upon harder material than if it had fallen when the wooden floor first gave way.

The first quality that a fire-resisting safe should possess is strength in its construction sufficient to prevent its being damaged by a heavy fall, or sustaining injury through the plates warping from heat. This cannot be obtained unless the outer plates are at least a quarter of an inch thick (or upwards, in big safes), strongly joined at all the edges by stout angle-irons well rivetted to them. Other and more expensive methods are used to join the edges, and are doubtless better than the foregoing; but this is at once a cheap, effectual, and most generally used method.

Secondly, it is essential to make the safe as nearly air-tight as possible, to do which it is only necessary that the door should fit very closely at its edges, and that its inside face touches at every possible point the interior of the safe.

The third thing to be considered is the fire-proofing —the most important feature of the safe. Almost everything that one can think of has been either proposed or used for proofing—water, wood, paper, plaster-of-Paris, chemicals of all sorts, and many other things besides. But of all these what may be termed a combination of water and wood, in the forms of alum and sawdust, has been most extensively used.

There are two walls of wrought iron in the safe, and the intervening space has to be filled with a fire-resisting material, which may be either of a refractory nature, such as fire-clay, sand, or any other practically infusible slow conductor of heat; or it may be an absorbent substance

containing chemicals that will evolve moisture when heated. The former of these two methods is now seldom used except by makers of cheap common safes, who sometimes use clay, ashes, or mould. The evaporating system is generally adopted, and as a rule the absorbent material is common sawdust, with which is mixed ordinary alum, the water of crystallisation in the alum being gradually parted with under the continued heat generated by fire. Mahogany sawdust is preferred, as being less combustible than that of white woods.

At one time tubes of glass or fusible metal containing alkaline solutions were imbedded in the sawdust and were supposed to burst or fuse at a given temperature, but it was found that the glass accidentally broke or the fusible metal became corroded, and allowed the liquids to escape, thus damping the contents of the safe. But the mixture of alum with sawdust is open to two objections. Owing to the hygroscopic nature of sawdust the alum is liable to decomposition, thereby producing a certain moisture in the safe; and, secondly, there is of course a limit to the production of moisture from the alum when under the action of fire, after which the sawdust will become gradually dry, and although it may not actually ignite, it will become charred, and even red hot, under sufficiently continued heat. It is but fair, however, to say, as I have previously suggested, that such instances of continued heat are but rarely probable; yet, for the before-mentioned reasons, I prefer and use an *incombustible* material, very light and absorbent, and which does not possess the bad qualities of sawdust, but which is more expensive. Supposing the alum to become exhausted, there still remains the protection of a substance which is both infusible and a bad conductor of heat.

Of course the actual amount of resistance to fire depends largely on the capacity of the proofing chambers.

When advisable the thickness of these may be increased to any extent desired, or the safe may have several chambers, all containing proofing, or intermediate ones left as air-chambers only.

To sum up the qualities which are requisite to make a safe proof against an ordinary fire, it must, first, be made entirely of wrought iron; secondly, the outer plates must be at least a quarter of an inch thick; thirdly, there should be a space of three to four inches all round it of an evaporating non-conducting composition. With such a safe as this, properly put together, the general run of fires may be defied; but there are cases where extra precaution should be taken, and the safe kept in a brick, stone, or iron strong-room. No safe inside a strong-room has, to my knowledge, ever been destroyed; but many—always light ones—in warehouses or offices have had their contents burnt.

And here I would caution those not acquainted with the subject to put little faith in the tests, either public or private, that are sometimes made, unless they are conducted by persons quite disinterested. When it is done in this way of course the result is one that may, if certain conditions are fulfilled, be valuable; but so frequently are these 'tests' arranged, either by making a safe specially for a trial, by carefully packing its contents, or by constructing the fire in a particular mode, to turn out such wonderful successes, that it will be well not to rely upon anything but actual experience gained from the result of safes which have been known to be subject to an ordeal in the ordinary course of things. Plenty of such instances can be investigated, but it will obviously be unadvisable to give here the numerous results that have from time to time been chronicled by the daily papers and other publications.

It should be borne in mind that certain things are less

liable to injury from heat than others; and therefore it is that books will sometimes sustain no injury, whilst loose papers in the same safe may be more or less damaged. For this reason it is advisable that all parchments and papers be kept in a drawer or cupboard of a safe, as the second enclosure (though with no more fire-proofing round it) gives a slight extra security.

Another caution I would give is that, after being in one fire, a safe should not be relied on to resist fire again until it has been examined and re-proofed by the maker or a thoroughly competent person. The resisting properties are certain to be damaged, if not destroyed altogether; and although I know of safes still in use that have not been renovated since preserving their contents, I would not place any faith at all in their power to prove again successful.

The destruction of the Pantechnicon has presented an opportunity of fairly ascertaining the effect of great heat upon various safes, and, strange as it may seem, scarcely one of the many safes survived the conflagration without injury. One French safe had nothing but its four sides left intact, its front, back, and inside having disappeared as if driven out by a cannon-ball. The cast-iron safes, of which there were several, proved, as might be expected, utterly useless, being found when pulled out of the ruins twisted into all sorts of shapes, or cracked and broken like glass. Other safes, by makers whose reputation can hardly be affected by damage done in such an unprecedented fire, had their contents very seriously injured; and only a few safes came out of the trial in at all a satisfactory state.

Speaking of French safes, I may here say that, as a rule, they and most of the Continental safes cannot be trusted in English fires, nor against the more advanced skill prevailing among our English thieves. Without

offence their character may be summed up as being really 'French'—pretty in outward appearance (which is more than can be said for our safes), with peculiar locks requiring no keys, and certain other un-English things about them; they are quite unsuitable for our market, and *vice versâ* our British safes find little sale in France.

Safes and other receptacles to contain gunpowder and preserve it from explosion have recently been talked about; and there is no doubt that one result of such a calamity as the late Regent's Canal explosion will be to expedite legislation on the subject of the transit and storage of gunpowder and other explosives. It may appear curious that gunpowder can be preserved from damage by fire with much greater ease than such a substance as parchment, but the former can only be destroyed by being in contact with actual fire, or becoming subject to a most intense heat (about 560 degrees); while a moderate heat or exposure to steam, such as is necessarily generated by the fire-proofing of a safe, often irretrievably damages parchment. A well-made safe, on the principle of evaporation already described, may be relied on to preserve gunpowder from considerable heat, but to avoid the possibility of flame or sparks entering the space round the door, a second safe of lighter make may be placed inside the ordinary one. Major Majendie, in a recent report to the Government on this subject, suggests that there should be public trials by the various makers, of safes, such as they severally think most suitable for this special purpose. It remains to be seen if this advice will be followed, and if so, upon what principle the trials will be conducted, and whether the safes or chests so tested will be precisely the same as the makers intend to retail, or are made specially for the occasion. It is extremely doubtful if the Government would be acting wisely in affording facilities at the public expense for private firms

to experiment with safes the merits of which are pretty well known; but should the trials take place, no doubt the results will, in some instances, be of a nature to astonish those not practically familiar with the action of fire in such cases.

CHAPTER V.

SECOND-HAND SAFES, ETC.

In the broadest sense of the term there cannot be such a thing as a burglar-proof or fire-proof safe, but in the usually restricted sense of these words it is easy to obtain a safe that combines both qualities, provided what is considered to be a good price is paid.

But it will be well to begin by warning those who hunt after so-called second-hand safes that a real second-hand one, by a good maker, is seldom to be obtained; also that the majority of safes advertised and sold as genuinely second-hand, and with which a warranty is often said to be given, are absolutely worthless, being made by small makers in London and Birmingham, chiefly on purpose to be sold as second-hand, and constructed of the lightest and poorest materials. The parts that are visible of these safes of course look strong; for instance, the edge of the door is sometimes about an inch thick, thus making it appear as if of that thickness throughout; while the fact is that the door is made of two thin sheets of iron with a thick narrow bar all round the edge, thus showing apparent strength where there is none in reality, for nothing is easier than to drill through this door and force back the bolts.

It is well for the reputation—such as it is—of these second-hand safes that they are covered with paint; the more the defects the nicer the safe frequently looks,

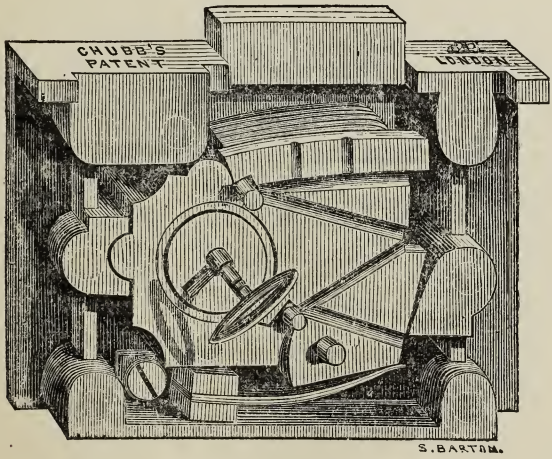
outwardly: for it is easy enough to cover up cracks, bad joints, &c. with putty, and then paint it all as smooth as a carriage-panel. The angle-iron, by which the plates are fastened together, is very slight, the rivets are small and few and far between; the plates themselves are but sheet-iron, often of less thickness than the mere linings of good safes; and as for the fireproofing material, it is sometimes the ashes from the hearth, and sometimes garden-mould. It is a fact that, at an auction in Scotland, whilst a safe of this description was being 'put up' as one of the best ever made, it suddenly fell to the ground, broke open in the fall, and out came the fireproofing in the shape of fresh garden-turf, with live worms in it.

At a dealer's at the West End of London, within the last few months, there was one of these *new* second-hand safes, its outer plates being less than an eighth of an inch thick. The safe, about five feet high, was so top-heavy and badly made that upon being touched it rocked like a jelly, and had to be supported by boards at the back. Such is a sample of many a wretched safe bought by unsuspecting and naturally ignorant customers.

As to the fastenings of such safes, the bolts are two or three in number, thrown to the front of the door, while at the back of the door are what are called 'dogs,' that is, immovable bolts, of little or no use, and put in merely to make the fastenings look stronger. The hinges, too, which ought to be well-made and of the best wrought-iron, are of cast-iron, so that not only does the movement of the door quickly wear them away, but a sharp blow would at once smash them in pieces.

The lock, which is generally used as a bait to catch the purchaser, is frequently of good make, but of a kind never intended for a safe. Locks made for wooden drawers are constantly bought and used for this purpose, although totally unsuitable, and in spite of all proceedings that can be

taken to prevent it. Neither my firm nor any of the large safe-manufacturers make safe-locks for any but safes of their own make. A lock for this purpose requires to be, first, very strong, and protected by hard steel, so as to be drill-proof; second, completely gunpowder-proof; third, simple in construction, so that it may never be liable to derangement. Locks on such safes as we are now describing are seldom anything but the last, and not always that. So weak and poor in its construction is this most important part of most of these safes, that workmen with the simplest tools have, with ease and without noise, forced open many of them in from five to fifteen minutes. The lock most suitable for safes is shown in annexed engraving.



It is, in short, a most obvious truth to all who care to enquire into the matter that of all cheap things a cheap safe as a general rule is the most worthless.

Every lock or safe maker of any repute has, at one time or another, had his name used unlawfully in order to deceive purchasers of these common safes. My firm has

been compelled to bring nearly a dozen actions in cases of this kind. It had a case lately in which a dealer attempted twice within twelve months (the second time in defiance of the injunction previously granted against him) to sell most worthless goods as being Chubb's patent make.

I had thought of giving a few instructions to guide a purchaser of a second-hand safe, that he might secure the best; but, as I believe it is a pure waste of money to buy even the best of the class alluded to, I will note what will assist the purchaser who desires a good safe by a good maker.

First, be satisfied that the lock is gunpowder-proof, and covered by some arrangement that will effectually prevent drills reaching it; then that the spindle or handle is made so that it cannot be pulled out or forced in. There ought to be at least three bolts at the front and three at the back of the door, proportionate to the height of the safe. The lock-case, containing lock and bolts, should be most strongly fastened to the door-plate, which ought never to be less than $\frac{1}{2}$ in. throughout. Respecting the body or outer plates of the safe, these should not be, in smaller safes, less than $\frac{1}{4}$ in. thick, while in safes above 5 feet high they should be at least $\frac{3}{8}$ in. The frame on the safe (for the use and description of which see page 35) must be at least $2\frac{1}{4} \times \frac{1}{2}$ in. in small, and $4 \times \frac{7}{8}$ in. in large safes. The rivets used ought to be no more than 3 inches apart; this may sometimes be tested by scraping off the paint, when the rivet-heads may be seen. Attention should be paid to the holes in which the bolts go, for unless these are strong, a wedge and crowbar would tear the bolts out of them without difficulty. Be sure also that the fireproofing is of the best material; and lastly, choose a safe of the best finish in every respect.

It may be said that notwithstanding the disparage-

ment of the cheap second-hand safes some of them have at times resisted burglars or preserved their contents from fire. This may be true, but it has been owing rather to the burglars' want of skill or the little risk they ran in the fire. On the other hand, I could cite dozens of instances where their worthlessness has been shown under real exposure to fire or the attempts of burglars.

A tolerably correct guide in the purchase of a safe is its weight, wherein the light plate and thin proofing cases are sure to betray themselves. Insist upon the weight being stamped on the safe, and see that it does not deviate largely from the following instances :—

	In. wide		In. high		In. deep			Cwt.	
A safe	22	×	17	×	16	should weigh about		3	
,,	44	×	28	×	24	,,	,,	11	
,,	48	×	39	×	25	,,	,,	16	(folding doors)
,,	60	×	39	×	26	,,	,,	23	,, ,,
,,	84	×	48	×	30	,,	,,	42	,, ,,

No safes of the sizes mentioned should weigh less than these amounts; but safes lined with steel, and made stronger than usual in other ways, will, of course, be very much heavier.

It is so easy for a safe to be made that will deceive any but an experienced eye, and when one is bought it is so requisite that it should be one to be trusted in, that if only for the sake of peace of mind it is advisable to purchase from one of those firms whose reputations depend upon the quality of their work, and whose name is a guarantee that the safe is a safe.

A guarantee is a capital thing to bait a hook with in most trades, but it is a doubtful advantage at the best, for if an article is not good enough to stand upon its own merits a guarantee cannot improve it; and to say broadly, 'Oh, yes, we guarantee this to be fire and thief proof,' is

to warrant a safe to withstand any amount of fire and any number of burglars.

There obviously must be a limit to the endurance of safes; therefore a guarantee is as obviously an absurdity, and ought not to be blindly believed in.

CHAPTER VI.

STRONG-ROOMS.

In the planning and construction of a strong-room it must be remembered that the object sought is to obtain a place secure against both the attack of thieves and the ravages of fire.

There are many cases, however, where the latter is the chief object; and as the attainment of this is more difficult than the former, it will necessarily come before us more prominently. In many respects this subject is the most important in this treatise, and it is one concerning which there is a great amount of ignorance. Bearing in mind the rapid spread of banking and other businesses requiring the security a good strong-room affords, it will be my object to show the faults of many constructions now relied upon, and to suggest the simple ways by which they may be avoided.

Building a single strong-room is a very different matter from erecting a fireproof building; the latter is a larger and more difficult question, which will be noticed by itself; but the room that is to be made secure may be and generally is part of a building with no pretensions to special safety against fire or thieves.

Now, the first thing to consider is the position best adapted in any bank, mansion, or warehouse for placing the more valuable part of its contents. There may be certain parts which seem most convenient for access or

other reasons, but such considerations ought never to be taken first, especially as the best place happens to be often rather inconvenient. The basement is undoubtedly the right position; any part of the basement will do, but a room on the ground or first floor has at once a source of weakness in itself, for it has to depend for support on what is not a strong-room. Let some spot be chosen in the basement where, if possible, the room will have none of its walls adjoining any other buildings. Should it be next to a street or thoroughfare, it will not matter; but it should not adjoin a court or area, where burglars might have an opportunity of working unobserved. It would undoubtedly be an excellent precaution to build all the walls quite distinct from the main walls of the larger structure, but this is not absolutely necessary, and the extra expense is a drawback to it, though I would give a caution against false economy in such a matter as this.

Any position likely to be damp should be avoided; but if this is not possible every precaution should be taken to remedy the evil, for the trouble caused by damp when once it has got into a closed room of this kind is endless. A few air-bricks connecting the inside by a hollow flue formed in the wall, with its outlet as far as possible from the inlet, should be sufficient to ventilate any strong-vault. But if other ventilation is necessary in the room, have a jet of gas always alight; and over the gas place a bell-shaped covering communicating with the outer air, or with a chimney flue in preference, by a two-inch iron pipe.

In excavating for the foundations, if the subsoil and the situation are not well known, it is important to see that there is no drain or pipe of any sort under the surface, and that the ground is stiff enough for the heavy weight that will be on it. One of the most important parts of a strong-room is the floor, although there is a

popular delusion that because it is the floor it is quite secure without any protection. A circumstance showing the necessity of being careful to make the floor strong occurred in the early part of the year 1865, at Hong Kong. The Central Bank of Western India, situated there, had a strong-room for its securities, but unfortunately the defence of the floor seems to have been forgotten. Accordingly some thieves commenced to make a tunnel from a neighbouring house, and after considerable labour obtained entrance through the floor and carried off plunder to the amount of fifty thousand pounds. The affair was managed during Saturday and Sunday by means of this tunnel dug between a drain and the floor of the treasury, a horizontal distance of sixty feet.

A New York bank was also entered in a similar manner, through an excavation which must have taken two or three weeks to make. Although such approaches may occupy some time, they can be carried on unnoticed until the removal of a stone in the floor is at last only the work of a few minutes. For the floor to be secure, it should certainly be formed of half-inch boiler-plates rebated and fastened together, laid upon a good thickness of brick and cement. Stone has been constantly recommended and used for flooring, but it is not advisable ; there ought not to be any stone in a strong-room except for the sill and lintel of the doorway, where it is almost necessary.

The walls must be at least fourteen inches thick, brick and cement, and there ought to be the boiler-plate lining inside wall and roof to correspond with the floor.

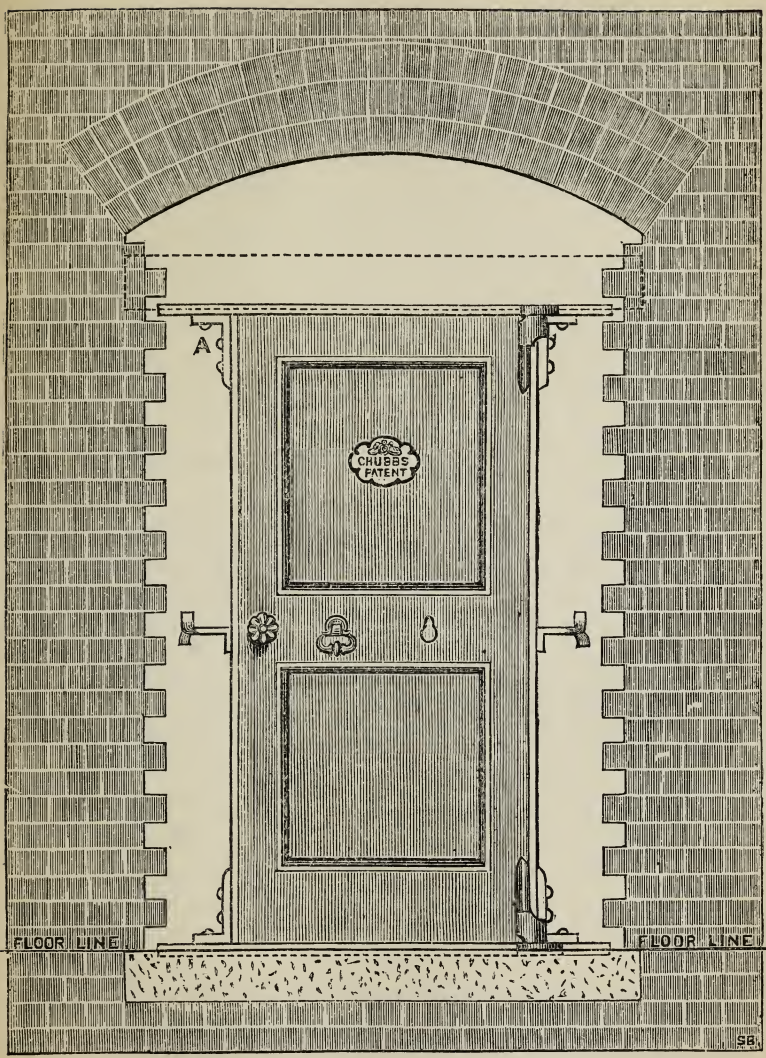
The roof must be brick-arched, and the arches should be made in the strongest possible way, in order to resist if necessary the weight of a great portion of the building above falling on them. If the span cannot be from one wall to another, then a wrought-iron girder may be introduced, but should be most carefully covered by cement or

plaster at every exposed part. On no account use a cast-iron girder.

The entrance to the room has to be well protected, for it is here that attack is to be expected from thieves, and that fire might possibly creep through.

The best plan is to use a fire-resisting door and gate joined together; the door being flush with the outside of entrance and opening out, the gate flush with the inside, and opening inwards; as a general rule the door only is used, but the addition of a gate not only gives extra security, but allows the door to stand open in the day-time to ventilate the room, when other openings for ventilation are impossible or undesirable. There certainly should not be any other *direct* opening besides the doorway either for light or air. Light is, I know, frequently desirable, but if it is obtained through a window or skylight the strength of the room is lessened, even if these openings have strong iron shutters. If gas is to be introduced the pipes must be laid on with care; it is best to have no pipe inside, but a swing bracket outside the entrance, which, when the door is open, can be swung through the opening and thus light up the interior. Fixed lamps may be used, but there is a certain amount of risk—though it is small—of their being forgotten, and of sparks from them igniting loose papers. It will follow from this that no stove or fireplace should be used inside a strong-room; for if there is a flue a source of weakness is introduced, besides the contents of the room being liable to damage from fire.

But the fixing of the door is an important and hitherto much-neglected point. The annexed drawing shows almost at a glance the proper mode of doing this:—



I have taken it for granted that it is understood iron doors are made with a frame surrounding them of bar-iron, to which the hinges of the door hang, and the corners of

which project, to give greater strength. Now, if this door and frame be fixed while a building is in progress, the locks and bolts are exposed to injury from dirt and damp, and the frame is liable to be thrown out of position by settlement of the wall. It is, therefore, better to leave such an opening as shown in the engraving sufficiently large for the intended door-frame, toothed at the sides, and having an arch above it. The door can then be fixed when the building is nearly ready for occupation, the surplus opening being filled with brickwork. The drawing shows a stone sill, and it is usual, though not necessary, to fix a stone lintel over the top of the door, as shown by dotted lines; or the arch may all be filled with brickwork. The bottom of the frame should be grooved about two-thirds of its thickness into the sill, leaving enough room for the door to open clear of the floor-level; or if it be wished to let the bottom frame entirely in, the same end may be obtained by slightly sloping away the floor outside it. The top and sides of the frame should be rebated into the head-stone (or brick) and jambs the whole of their thickness, so that the inside of the wall-opening may be flush with the inside of the frame.

The door must be placed level and upright in the position prepared for it, and temporarily supported there; it should be received from the makers locked, and must have its brass furniture fixed, and be unlocked by the key before attempting to turn the handle of the main bolts. If after unlocking it there is any difficulty in turning the bolts back with the handle, no great force should be used, but the position of the frame must be adjusted until the bolts move easily and the door opens without binding anywhere. In case of any such difficulty, a little wedging up of the top arm against the shutting side of the door (marked A in drawing), will usually remove it. Try the

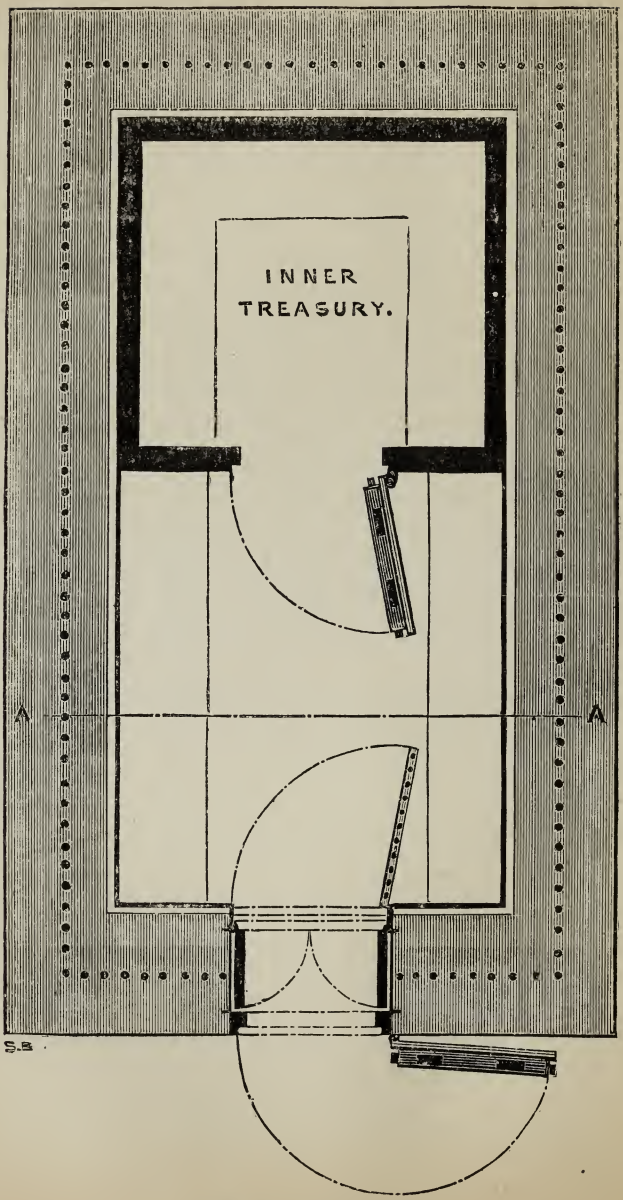
door with a spirit-level applied to three parts, viz.: 1. The face or edge of frame (right and left sides), with door shut. 2. The inside shutting edge of frame, with door partly open. 3. The inside of bottom of frame; and adjust until the bolts work properly. It should then be fixed in this position, taking care not to force the sides of the frame inwards while so doing.

During the fixing, the opening and shutting of the door should be tried frequently. As cement swells in setting, it is possible a door-frame which appears to be properly set may afterwards be found bulged or bound when dry. This should, therefore, be guarded against by wood struts placed across the inside of the frame. On no account must a frame be fixed without its door, but always with the door hung and open, in accordance with the foregoing directions.

As the keys are not required by the workmen after the door is unlocked before fixing, they should be kept by the owner, lest by being left about they may be mislaid or wrongfully used.

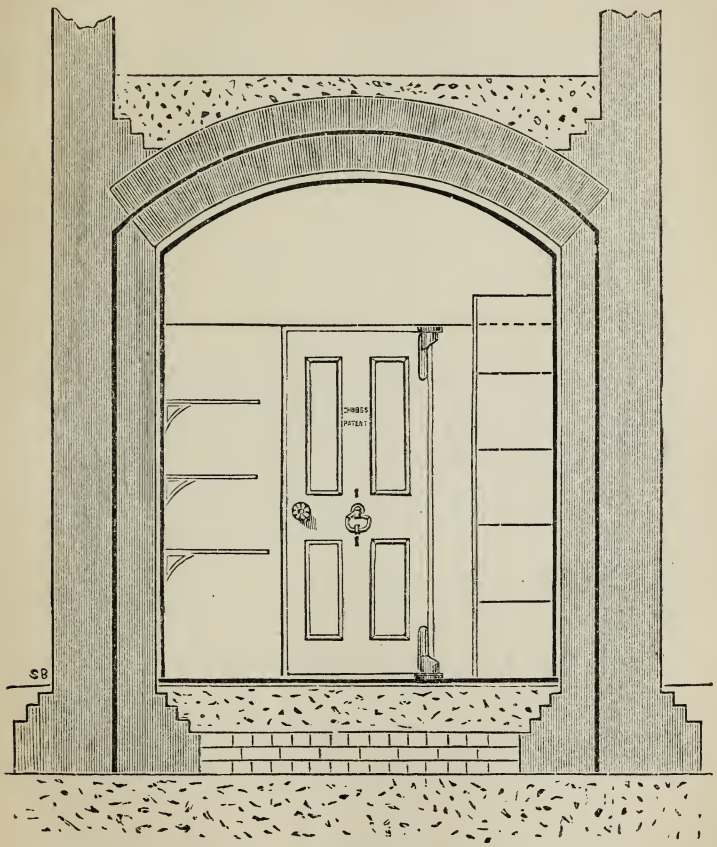
A strong-room door of ordinary quality should have the outer plate $\frac{1}{2}$ or $\frac{5}{8}$ inch thick, with the lock-case and fire-proofing-case in addition; and at least six bolts, three at front and three at back; the frame of a strength proportionate to the size and weight of the door, and with arms and lugs projecting, to build into the wall.

The interior fittings of the room are of course determined by the requirements of the owner. If there is much shelving it may be of perforated metal or mere strips of iron for boxes to rest on, so as to allow of free circulation of air. For particularly valuable articles or documents a safe either small or to take to pieces may be introduced, as is usually done by bankers. I give a plan of a first-class strong-room, which for all practical purposes is secure, and combines strength with economy in construction.



PLAN OF STRONG-ROOM.

The side and back walls are about 2 ft. thick, in hard brick laid in cement. At 9 inches from the inside of wall is a continuous rough iron grating of vertical bars, built



STRONG-ROOM—SECTION ON LINE AA.

in as a part of the solid wall. Hoop-iron is used in the horizontal courses. The entrance wall is $2\frac{1}{2}$ ft. thick, but in other respects similar to the side walls.

The roof is formed of a brick arch 18 inches thick, with curved bars in the centre; and is covered with a layer of concrete.

The floor is brick and concrete as shown; with a layer of asphalte on the surface.

At the entrance to the room is a steel door of great strength, with two locks throwing 12 bolts, and with a fire-resisting chamber. Next to this is a pair of iron folding-doors, not fireproof; which, when open, lie within the thickness of the wall. There is next a wrought-iron gate opening inwards; the frames of the doors and gate being all connected by wrought-iron plates.

In the room itself, at the further end, is a fire-resisting iron and steel strong-room; and the space in front of it (sides, roof and floor) is lined with $\frac{1}{2}$-inch iron plate, placed a slight distance from the wall to allow of an air-space between. The fittings are of iron; shelves on one side and cupboards on the other.

The cost of such a room complete, of the best materials and highest finish (including brickwork), would be about 1300*l.*

The following is a condensed description of a strong-room constructed a few years ago for a London bank, and which might serve as a model for others. The walls, two feet thick, are formed of hard bricks laid in cement, with hoop-iron worked in. The room is lined throughout with wrought-iron, $\frac{1}{2}$ inch thick. There are two doors, the outer one a strong iron one, with two locks; and the inner one of combined iron and steel, of extraordinary strength, with two locks throwing ten bolts. A safe placed inside, weighing eight tons, and having twenty bolts, contains the cash and securities. An alarum in the resident clerk's bedroom is attached to the inside of the strong-room, so that if the outer door be opened a gong is set going. A

porter sleeps on a bed in front of the outer door, and by pulling a handle he can set the alarum off if necessary; and there is a watchman always on duty. With such a room as this, situated in a building constantly and carefully watched by trustworthy servants, robbery is made practically impossible.

As an instance of what peculiar inventions are sometimes brought out, I annex a description of McNeill's Patent Safe, which seems to be a sort of floating strong-room for the preservation of mails, specie, and other valuables during transit on shipboard from shipwreck, fire, and theft; but it will be seen to be rather a curious contrivance, and hardly capable of general adaptation, to say the least. The object of the invention, it is stated, is to meet a want which has long been felt, viz., the safety of mails, specie, &c. on board vessels at sea. By the ordinary system of carrying these, the public have had to put up with the inconvenience of occasionally losing or receiving in a damaged state their letters and despatches, and underwriters have had to pay large sums on the total or partial losses occasioned by the wreck or burning of vessels containing large amounts of specie.

The safe is constructed of steel or iron plating, lined with wood, leaving a space, which is filled with fire-resisting composition, of a rectangular form and dimensions suited to the position in which it is placed—say between decks of a vessel—and is placed inside a steel or iron case attached to the main deck, and running up through the upper deck, forming a hatchway large enough to admit the safe to pass through, being held in position by guides fixed at vertical angles, forming slides.

The door of the safe is supposed to be both water-tight and fireproof. When the safe is placed within its case, the upper part of which forms a hatchway, it may

be covered either with an ordinary hatch-cover or a deck-house corresponding with other houses on deck, and secured down with hook-bolts fixed to the sills of the hatch-cover or house, and engaging into eyes rivetted into the sides of the case or hatchway. The hook-bolts are connected by iron bars, and communicate with a strong cross-bar, to which is attached a powerful lever placed close to the top of the safe.

In the event of foundering, as soon as the water inside the vessel reaches the upper deck it will flow into the case through holes provided for that purpose; the safe will ascend the slides, forcing up the lever, which will disengage all the fastenings of the hatch-cover or house, and permit the safe to lift it off, and float away clear of the vessel as she sinks.

Strong ringbolts are provided on the top of the safe for lifting it in and out of the case; also for towing or lifting on board any vessel finding it adrift. The boats of the sunken vessel may be made fast to the floating safe, which will serve as a buoy, keeping them altogether with their heads to the sea, with a much better prospect of being seen and picked up by a passing vessel than if scattered over the ocean. The name of the vessel to which it belongs painted on the door of the safe would lead to its restoration to the proper quarter.

I am not aware that this peculiar invention has ever been carried out, but the idea which probably gave rise to it is one that has never been thoroughly solved. Ocean-going mail-steamers, as a rule, continue to carry enormous sums of bullion in such a way that if the vessel is wrecked (as is too often the case now-a-days) the money is scattered and lost. The plan of making a small so-called strong-room by partitioning off a part

of the vessel, is open to many objections, and is far inferior to the practice of having strong iron safes, which can be recovered if the vessel should be lost in comparatively shallow water. When the terrible wreck of the 'Royal Charter' occurred there was a large quantity of specie on board, and all that had been deposited in a safe was recovered uninjured by the divers many weeks after, while the loose money was scattered.

CHAPTER VII.

FIREPROOF BUILDINGS.

I. *General Construction.*

When such buildings as the City Flour Mills and the Pantechnicon—types of many other and similar structures in London and the provinces—are burnt out, in spite of their supposed fireproof qualities, it becomes a question of lasting importance as to what is the cause of failure, and whether any so-called fireproof buildings are really so or not. The panic caused in many minds by the newspaper reports of such disasters lasts but a short time, and the true lessons are seldom learnt. With the object, therefore, of endeavouring to place certain facts and suggestions on permanent record, I have collected from many sources various particulars connected with this subject—so intimately connected with the manufacture of fire-proof receptacles.

Much that has been written on fireproof construction is of little value, because the practical bearings of the subject have been lost sight of, and theories of construction are broached that may be good in themselves but cannot be brought into use, because of expense and other inconveniences.

I remember, for instance, some gentleman recommended that every room of a building should have floor, walls, and roof lined with galvanised tanks of water, connected by an elaborate system of pipes and so on—not

at all a bad idea, but utterly impracticable for business purposes. Another suggestion was that there must be no windows in a building, as through them a draught passes to increase fire.

But in these instances, as in many others, the main fact is forgotten, viz., that what is wanted is the best possible mode of making a fireproof structure that is also adapted for ordinary business purposes. This is what I take to be the point. Cases where exceptional security from fire is needed seldom occur and are more easily met. Dealing, therefore, with an ordinary warehouse, which is to be a fireproof building, it should be remembered that its fire-resisting qualities are determined not only by the materials of the actual structure, but also by its interior fittings, and, above all, by the goods stored or manufacture carried on in the place. A house of brick only obviously will not burn, but fill it with cloth or cotton goods, and the house as well as the goods may be destroyed. No hard-and-fast line can, therefore, be laid down, for every case may be different. I will endeavour to notice the *risks* of buildings commonly erected and the remedies for each—a combination of which remedies will make a good fire-resisting structure. Among the numerous books and papers on fires to which I have been able to refer I have found no information so clear, precise, and practical as that to be had from the late Mr. Braidwood's [1] paper, read before the Society of Arts in 1856, and the excellent book entitled 'Fire Surveys,' by Captain Shaw, the present Chief of the Metropolitan Fire Brigade. Mr. Braidwood laid down

[1] Mr. Braidwood was at the head of the London Fire Brigade; and, after a hardworking and useful life, was killed at the post of duty during the great Tooley Street Fire in 1861, by the sudden collapse of a wall. This fire burnt for a fortnight, and caused the loss of property valued at 2,000,000*l.* sterling.

certain rules, which have never been improved upon ; while both he and Capt. Shaw express views so alike, and with the confidence of men who have gained their experience from actual results, that it seems better to be guided by them than by all other writers put together. Not that I would disparage these latter, for it is well known that there are architects and others who have contributed much to the solution of the mystery which was so long attached to fireproof building. Mr. Braidwood gives a comparison to demonstrate that what would be safe construction for one building would not be for another. He says : 'Supposing an average-sized dwelling-house, $20 \times 40 \times 50 =$ 40,000 cubic feet, built with brick partitions, stone or slate stairs, wrought-iron joists filled in with concrete, and the whole well plastered. Such a house will be practically fireproof, because there is no probability that the flooring in any one room would make fire enough to communicate to another. But suppose a warehouse equal to twenty such houses, with floors completely open, supported by cast-iron pillars, and each floor communicating with the others by open staircases and wells ; suppose farther that it is half-filled with combustible goods, and perhaps the walls and ceilings lined with wood. Now, if a fire takes place below, the moment it bursts through the upper windows or skylights the whole place becomes an immense blast-furnace ; the iron is melted, and in a comparatively short time the building is in ruins ; and, it may be, the half of the neighbourhood destroyed.'

Such a warehouse, as here described, is the type of many now in existence, and yet people wonder how they can burn. The wonder is rather why so few are burnt ; and one explanation is, that the majority are scarcely used when gas and lamps are required, the hours when the workpeople and clerks are about having been so much restricted that for at least a great part of the

year the work does not extend beyond daylight. When a fire has once got hold of a warehouse, unless it is built in compartments, the firemen can do nothing but prevent its spreading to adjoining erections; and, as this cannot always be done successfully, a badly-built warehouse is likely to bring disaster upon its neighbours.

But a building may be built to give security; and Mr. Braidwood's opinion was that 'the real fireproof construction for such buildings is brick arches, supported on brick pillars only.' This mode of building, however, involves so much expense, and occupies so much space, that it cannot be used with advantage. The next best plan is to build warehouses in compartments of moderate size, divided by party walls and double wrought-iron doors, so that if one of these compartments takes fire there may be a reasonable prospect of confining the fire to that compartment only.

Cast-iron is largely used in building because of its cheapness; but it is exceedingly dangerous, for it gives way from so many different causes that it is impossible to calculate *when* it will give way. The castings may have flaws in them, or they may be too weak for the weight they may have to support, being sometimes within ten per cent. or less of the breaking weight. The expansion of girders may thrust out the side-walls. For instance, in a warehouse 120 ft. × 75 × 80 ft. there are three contiguous rows of girders on each floor, with butt-joints; the expansion in this case may be 12 inches. The tie-rods to take the strain of the flat arches must expand and become useless, and the whole of the lateral strain be thrown on the girders and side-walls, perhaps weak enough already. Again, throwing cold water on the heated iron may cause an immediate fracture. For these and similar reasons the firemen are not permitted to go into warehouses supported by iron *when once fairly on fire.* The effect of fire on cast-iron,

as stated by the late Sir William Fairbairn, F.R.S., of Manchester (Seventh Report of the British Association, vol. vi. p. 409), is, that the loss of strength in cold-blast cast-iron, in a variation of temperature from 26° to 190° = 164° Fahr., is 10 per cent., and in hot-blast at the variation of from 21° to 169° Fahr. is 15 per cent. Now, if the loss of strength advances in anything like this ratio the iron will be totally useless as a support long before the fusing-point is attained. Respecting the strength of cast-iron columns here alluded to, I may state that Capt. Shaw says: 'At a temperature of 212° Fahr., or the boiling-point of water, cast-iron loses 15 per cent. of its strength. At the temperature of molten lead, 612° Fahr., it has probably no strength at all; and at the temperature 2,787° Fahr., which is probably much below that of the centre of a large building, it becomes liquid.' A very clear proof of the inability of cast-iron to resist the effects of fire was given at the destruction of a chapel in the Liverpool Road, Islington, on Oct. 2, 1848. The chapel was 70 feet in length and 52 feet in breadth, and was completely burned down by a fire which commenced in a cellar. After the fire it was ascertained that of thirteen cast-iron pillars, used to support the galleries, only two remained perfect; the greater part of the others were broken into small pieces, the metal appearing to have lost all power of cohesion, and some parts were melted. It should be observed that these pillars were of ample strength to support the galleries when filled by the congregation, but when the fire reached a certain point the pillars crumbled under the weight of the timber only, lightened as it must have been by the progress of the fire. In spite of such a case as this, which is but an example of what has often happened to other buildings, cast-iron continues to be used not only for ordinary purposes but actually for so-called fireproof buildings. It may safely be asserted that *no place*

in which there are unprotected iron-supports can possibly be fireproof; and if this test is applied to many erections thought to be secure, it will soon be seen how few there are that can be relied upon to withstand excessive heat.

The reckless mode of running up houses, as speculative builders appear to delight in doing, and supporting the front on light columns, is a most dangerous proceeding. Capt. Shaw has cited a case of a corner building lately put up, 90 ft. long and 70 to 80 ft. high, supported entirely on iron columns, without any wall, wood, or brickwork. There is no doubt that at the ordinary fire temperature of 600° to 700° Fahr. the whole building must inevitably fall down, and such a heat could easily be created by the combustion of a very small quantity of household furniture. The fashion of having all the available space for large shop-fronts gives rise to this dangerous work. Most of the elaborate shops and offices lately built in London depend entirely upon iron supports; and some day, when a fearful accident is the result, the public will appreciate the danger.

In the early part of this year large corner premises were built not far from the Elephant and Castle, in the South of London, and I watched their erection with some interest. The house of four storeys was run up (a better term than built) in a month. The corner angle is supported by two thin iron columns, and between these and the other ends of the building are two wooden posts, but the weight chiefly rests upon the iron columns, which are most certainly unable to sustain the tons of brickwork above it in case of severe fire. As long as architects and builders and their employers give up security for the sake of economy and space, this sort of work will continue to be put up, unless interfered with by a new Building Act.

What ought, then, to be used for supports? If the brick columns are inadmissible, then, strange to say, wood

posts are the best, or an iron support, well protected by brickwork, cement, or plaster. The fact is, though iron is incombustible, it is itself not fireproof; and, on the other hand, though wood is combustible, it may be used in such a manner as to resist fire for a great length of time. Capt. Shaw's recent experiments with a wooden post had such an extraordinary result that, with his permission, I append the particulars, from a letter of his inserted in 'The Times':—

'A few months since a fire occurred in one of the enormous warehouses for which the docks in this metropolis are remarkable, and raged with great fury from a little before six in the morning till about eleven in the forenoon, when it was extinguished, and a very large proportion of the building and its contents saved. The warehouse was constructed of brick walls; it had wooden floors, supported on wooden beams, which, in their turn, were carried on wooden storey-posts about twelve inches thick; and although serious damage was done, not one portion of the heavy woodwork was destroyed. After the fire I was allowed to remove one of the storey-posts, with a section of the beams, and other parts surrounding it above and below. This post had been subjected to the full action of the fire during the whole of its duration, as already mentioned; or, making full allowance for everything, including the delay of the fire attacking the particular spot on which it stood, and the time at which the cooling process commenced, certainly not less than $4\frac{1}{2}$ hours.

'As we had used large quantities of water, and it was probable that the wood might have been somewhat saturated, I had it carefully dried for several days before a strong fire until not a trace of moisture remained in it.

'I then set it on end in an open yard exactly as it had stood in the warehouse, with the pedestal underneath,

the cap above, and the beam across the cap; placed more than a ton of shavings, light wood and heavy wood, round it, and after saturating the whole heap with petroleum applied a light to it. After this I kept men pumping petroleum on it until my stock was exhausted. At the end of $2\frac{1}{2}$ hours I withdrew the post, beam, and other parts from the fire, and within a few minutes from the time they were withdrawn they ceased to burn.

'I then sawed off, horizontally, a few feet of that part which had suffered most from the flames, and afterwards split the same piece longitudinally with steel wedges, in order to examine its condition.

'The post was of pitch-pine, about the most inflammable wood I know, and yet after exposure to fire for seven hours, the fury of which could not be exceeded except in blast-furnaces, it contained, and still contains within it, a quantity of uninjured and apparently fresh wood, probably capable at this moment of supporting the whole weight which the original post may have been designed to carry.

'Immediately after the saw-cut, and again after the cleaving with steel wedges, I carefully examined the centre, and found it just perceptibly warm to the touch, but nothing more, thus proving that the fibre, in which the strength lies, must have been quite uninjured.

'The lessons to be drawn from this I take to be as follows: A massive storey-post of even the most inflammable wood is absolutely and perfectly proof against any heat that can be applied to it—will not of itself burn at all, but requires a continual supply of highly inflammable substance to keep it burning, and when the supply is withdrawn ceases to burn; and lastly, after being exposed to flames for seven hours of very great intensity, is not injured to a greater depth than about two inches from the

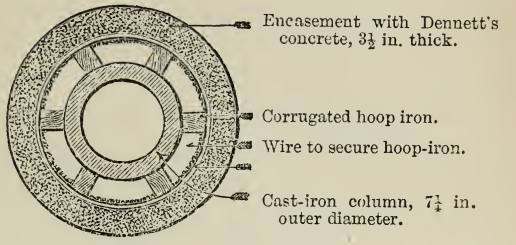
original outer surface, and still shows a centre as clean and fresh as when it was first put in.

'There may be other materials suitable for this purpose which are capable of resisting the effects of heat, and, if so, I hope we may one day hear of them; but, in the meanwhile, I venture to submit what I consider to be strong practical testimony in favour of massive timber for the internal supports of heavily-loaded buildings. Oak or elm is the best wood to use, and will defy destruction for hours.'

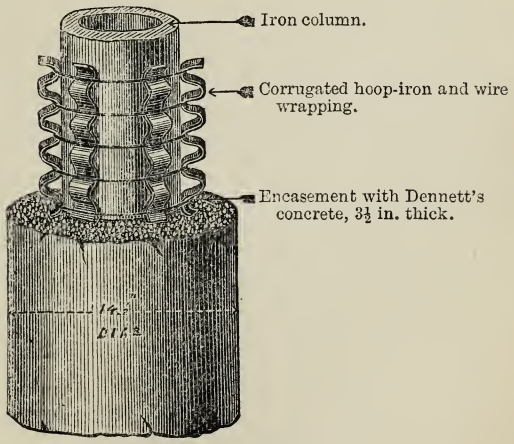
Messrs. Dennett, whose name is better known in connection with the Dennett Arch, have introduced a new mode of covering up iron columns in such a manner that they stand through intense heat, and have the advantage of being small in bulk. The accompanying engraving will make the following explanation clear.

Strips of corrugated hoop-iron are fastened at intervals by wire close to the iron column, and all is then encased with concrete $3\frac{1}{2}$ inches in thickness, made as described on page 86. An experiment was tried at Nottingham with one of these columns placed in a fire of wood and shavings saturated with gas-tar, and allowed to burn with a fierce heat for a space of $4\frac{1}{2}$ hours. When half the time had elapsed the column was thrown over, so as to lie horizontally in the fire, and have its whole length exposed to the flames. The fire was at length extinguished by water being thrown on, in order to make the test still more severe, but on examination the concrete casing had not cracked or broken in any part, while the column underneath, as soon as a portion of its covering could be removed, was cool enough to be handled with impunity. It will be interesting to note the development of this invention; for in the event of farther tests in actual practice being as satisfactory as that already named, it is likely to come into very prominent use.

The careless way in which chimneys are built is the cause of frequent danger. By communicating with each other in the same gable, fire will often spread and wrap the whole house in flames. One of the principal streets in


Encasement with Dennett's concrete, 3½ in. thick.
Corrugated hoop iron.
Wire to secure hoop-iron.
Cast-iron column, 7¼ in. outer diameter.

HORIZONTAL SECTION OF COLUMN A.



PART ELEVATION OF COLUMN A.

Edinburgh had scarcely a chimney-head that was not in this condition. The ends of joists or pieces of timber are sometimes allowed to protrude into chimneys, and then it is generally by accident if the building does *not* catch fire.

Buildings full of these and other 'scamping' work, and

so likely to spread fire around, are certainly opposed to the rule that 'a man may burn himself and his own property, but he shall not unduly risk the lives and property of his neighbours.'

Covering timber—that is, joists or the thin wood of partitions—with sheet-iron is often done, but it is quite useless. When it is known that the Pantechnicon floors were so covered, proof of its uselessness will be at once admitted.

It may be thought that an important fire-resisting substance has been omitted to be mentioned, namely, stone; for in many books, and even in Acts of Parliament, the expression 'stone, or other fireproof material,' may be found. But all competent authorities are now agreed that stone of nearly every kind is incapable of resisting the heat of ordinary fires; and when used for supporting weights, or even if hanging unsupported, as in a staircase, frequently is a source of great mischief and probable danger. A flight of stone steps, heated by the conflagration of the house in which it was situated, has been known to collapse immediately upon the admission of cold air through the outer door being suddenly opened.

Stone is therefore inadmissible for fireproof purposes, and should not be used for strong-rooms, or as supports for joists or for any part excepting the floor, where it may crack or crumble without affecting the rest of the building. Granite is, as far as experience goes, capable of resisting immense heat; and it is said the great fire at Boston, U.S., in 1873, was stopped when it came to a huge granite warehouse. But the cost of this material and working it are too great for it ever to be extensively used.

Concrete has been lately brought forward as a good, cheap, and fireproof material for making walls and floors, but if used it should be most carefully made; if broken limestone is used it will not be fireproof; but with a mixture of flints, brickbats, sandstone, pebbles, and cement

in suitable proportions, a good wall may be erected. One advantage it has over brick is, that being stronger (if plenty of hoop-iron is used as a bond), it occupies less space, and no plastering, or very little, is needed inside.

There has been no case, as far as I am aware, of a large concrete building being subjected to a severe test; therefore, unless other objects were aimed at, I should prefer a brick building. But some warehouses and mills are so large that brick cannot be used internally in arches; and a subdivision by party walls would destroy the business purpose of the building, and allow of only small compartments in it. Cannot iron girders be used in *any* way to make them safe? To a certain extent they can, if protected over the entire surface by cement or lumps of fire-clay. There should be but few employed, and allowance must be made for the girders, in case they get heated, to expand without thrusting out the walls. They should be supported on corbels of brick, and be as light as possible consistently with the strength required. If used as means to carry a wall they must be covered as suggested, and with the utmost care, for in this case any twisting or bulging sideways will endanger the wall above.

Whatever system of construction is adopted, there are three things not yet mentioned of high importance to the fireproof quality of the building; namely, the communication between the various floors, the style of window, and the construction of the roof. With regard to the first of these, there is little doubt that the ordinary staircase and the open lift are important aids to the spread of fire; by them the various floors of a warehouse are, when combustion begins, converted into so many furnaces with a connecting flue, and the extension of fire is accelerated by the draught rushing upwards. Though the stairs may be uninflammable and even indestructible, they will be in some measure a source of weakness, unless completely

separated from the open rooms, as shown in the designs engraved in the Appendix. For these designs of a thoroughly fire-proof warehouse, I am indebted to Mr. E. Hoole, of Russell Square, London; who has succeeded in planning a building adapted to commercial requirements, and yet possessing the necessary elements of a fireproof structure.

All openings must be fitted with *double* iron doors if perfect security is required, but with a single door if only ordinary risk is to be guarded against. The construction and fixing of these doors are a most important matter, and should be quite as carefully attended to as if the doorway were to a strong-room. Details of fixing them will be found in the chapter on strong-rooms, and the strength of doors should be the same as there shown. The outer plate of door being a half-inch solid boiler-plate, there must be an air-space behind it, partly occupied by the working parts of the lock, and inside that a casing of non-conducting material. The bolts should be six in number, three in front and three at the back, secured by a lock; and the frame into which they fasten must be solid iron, well built into the wall. The price of such a door, 6 feet high by 2 feet 4 inches wide, is 22*l.* 10*s.*, and money thus spent would many a time have saved thousands in property.

The Building Act can be complied with by providing a sheet-iron door with a plain barrel-bolt, such a division forming no security whatever, as the iron immediately warps, and allows flame or heat to pass through the opening. In this particular the Act has done much harm, for a false sense of security has been felt when its provisions have been met, and money has been wasted in buying, and labour constantly lost in closing and opening doors that are unable to hinder fire from spreading and ensure safety. Cast-iron hinges are sometimes used for these doors, giving

another element of danger. Not long since I saw the ruins of a building which had been divided in its various blocks by such doors. Most of the doors were down in the rubbish, while the openings where they had been high up on the walls had the broken hinges left in the brickwork.

No regulations for fireproof building can be complete without most stringent rules for using the best fire resisting doors, for what the door of a boiler-furnace is to the fire within, the door of a room is to combustion going on inside: it will, if insecure, allow air in to feed the flames so long as there is fuel to burn.

But there are other openings necessary to warehouses; and this leads to the subject of the windows, which are in the fireproof sense a necessary evil. The danger consists in the draught which comes through to feed the fire; but the risk can be lessened by using very thick glass, in small squares, and taking care that no broken panes are allowed to remain in the windows. If anyone takes the trouble to notice such a thing, he will scarcely find a warehouse without some broken squares, which will admit air enough to fan a fire to the temperature of a blast-furnace in a very short time.

Iron sashes should be used; and iron shutters may be also used to cover the windows, capable of being opened easily on the outside by firemen if required. Capt. Shaw states that heavy losses have been caused through the firemen being unable to open iron shutters from the outside, in consequence of their expansion from heat. He also gives a warning against the too common practice in cheap buildings of using glass with bullseyes or dents, through which the rays of the sun become concentrated and set fire, as has been the case, to the interior. Projecting or bow-windows must not be adopted, as fire can more easily pass in this way from one opening to another.

The remaining particular to be noticed is the con-

struction of the roof, by the falling in of which the destruction commenced below it is so often completed. The high Mansard roofs appear to have largely contributed to the destruction of Chicago and other American cities. It is somewhat alarming to see the extent to which they are being employed in England; but whatever form of roof is used, the materials of which the framing is composed should be incombustible, and the ceiling beneath it ought to be perfectly fireproof, so that fire beneath cannot ascend to the roof, or descend from the roof to the rooms. A fireproof ceiling is also valuable for preventing the building being deluged with water from the engines, when fire has attacked the roof only. If any openings to the roof are necessary, they must be constructed with care and placed in a room—not at the top of a staircase, as is so frequently done, where the draught of air is likely to be concentrated.

A mill at Leeds, at which a fire took place in 1827, was, with the exception of the roof, supposed to be wholly fireproof. The upper floor was filled with flax. The roof fell in, and the heat so affected the iron beams of the floor as to cause them to give way and involve the whole building in destruction.

In concluding the particulars of the general construction of fireproof buildings, I would again urge the use of brick, as the best known material for the purpose of resisting heat; or failing this, iron, protected by plaster, concrete, or brickwork. During the space of a few months there were calamitous fires in some large waterside premises, and at each of them Capt. Shaw states the following results were observed: 'The bricks were uninjured, the wood was seriously damaged, but only partially consumed; the iron was fractured, and consequently rendered worthless; and the stone was shivered into fragments and totally destroyed.'

CHAPTER VIII.

FIREPROOF BUILDINGS.

II. *Patent Systems of Construction, and their Application.*

Many of the suggestions in the preceding chapter have been embodied in the numerous patents brought out by engineers and others for what are termed 'Fireproofing Systems.' Among these inventions may be named Messrs. Moreland and Son's, Messrs. Fox and Barrett's, Mr. Nasmyth's, Messrs. Dennett and Co.'s, &c.

Messrs. Fox and Barrett's patent is one of the oldest, and is still largely used, having been, among other instances, recently applied to portions of the Criterion, in Piccadilly Circus. It consists mainly in substituting iron for wooden joists; and upon the lower flanges of these iron joists are placed pieces of wood, which bear the concrete filling up the space to the floor-boards or tiles above.

The other systems have all, more or less, ordinary concrete as a constituent part, depending largely for its support upon iron or wood beams, and thus probably being, after all, only fireproof to a certain point. One exception must be made in favour of the Dennett system, as in this is introduced a new concrete, treated in a novel and somewhat bold though successful fashion.

This system, known as the 'Dennett Fireproof Construction,' is one of great advantage, inasmuch as iron is

dispensed with as far as possible, while the space occupied by arched floors is reduced to a minimum. In some cases, indeed, no iron at all is wanted, and yet no room is wasted by heavy piers or supports of brick.

A very superior description of concrete is the body which forms the fireproof medium in this construction. This concrete, unlike that used for foundation and other purposes, is not mixed with any of the ordinary limestone cements, the action of which under fire is well known. A piece of the hardest limestone, when deprived by calcination of its carbonic acid, becomes a body which may be crushed by the least pressure, or if treated with water assumes double its original bulk and falls to powder. Concrete composed of the ordinary lime, inasmuch as it approximates, when set, to the original carbonate, would of course manifest the same characteristics under similar treatment. The concrete which forms the chief element of the Dennett construction has, however, for its cementitious component the *sulphate* of lime, a body which loses little of its cohesion by calcination. Experiments as to the character of this concrete prove that it remains intact though reduced to a white heat, and that the application of water while in that state does not materially impair its strength or cohesion.

The arch form is that which is usually adopted for the construction of floors (diagram A), the spandrels of

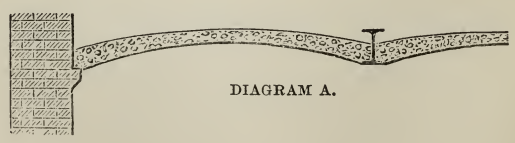


DIAGRAM A.

the same being, however, in some cases filled in with the material, so as to form a horizontal floor (diagram B). These arches, when thoroughly set, exert no thrust upon the outer walls, and, in fact, from their slight rise and

thoroughly homogeneous character, they possess as much the nature of a beam or landing as that of an arch. For this reason their use is, in many cases, advantageous, where that of brick arches would be altogether inadmissible. The arches are supported at the points where they abut upon the walls by projecting courses of brickwork,

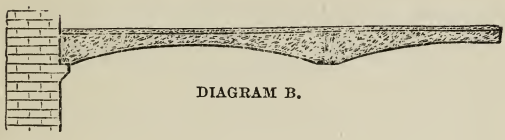


DIAGRAM B.

and at intermediate points by rolled iron joists or rivetted girders. They have a minimum rise in the soffit of one inch to every foot of width, and they are turned in this proportion up to spans of 10 or 12 feet. Corridors and cottage floors are formed in this manner without the introduction of any joist or beam whatever (diagram c);

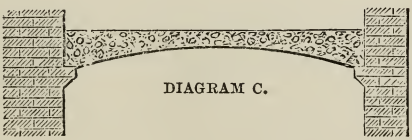


DIAGRAM C.

the soffits of the arches, after the removal of the centres, simply require to be finished with the last or setting coat of plastering. In cellars or other basement offices no extra coat whatever is necessary.

The floor or upper surface can be finished in the material itself, at a small cost, equal to stone in durability and appearance. When covered with kamptulicon or other similar material a floor at once noiseless to the tread and free from vibration is obtained. These qualities are, for banks and other public offices, very important *desiderata*. The arch may, of course, if preferred, be paved

with any other material, such as stone, tiles, asphalte, or cement.

Floors formed in the simple manner described are excellent in a sanitary point of view. They are clean, non-absorbent, and are non-conductors of sound and heat. These qualities particularly recommend them for adoption in hospitals, unions, barracks, and other large buildings; while for houses of the artisan class, especially in crowded districts, no other method of construction presents so many advantages.

If a flat ceiling is required, ceiling-joists are fixed to the lower flanges of the iron girders, and lathed and plastered in the ordinary manner (diagram D). It is

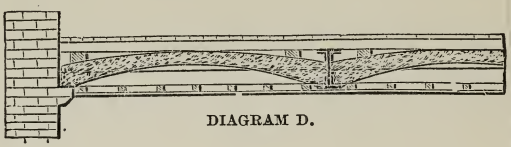


DIAGRAM D.

generally preferred, however, in buildings of a public character, such as banks, offices, &c., to leave exposed the lower flanges of the iron girders. This is the most constructional mode of treatment, and by the judicious application of coloured decoration a very effective ceiling is obtained. The ceilings of the bedrooms at Kelham Hall, Notts, a building designed by Sir Gilbert Scott, are finished in this manner. This mansion was made thoroughly fireproof on its re-erection nine years ago, after the destruction of the former building by fire. The ceilings of the reception-rooms are formed by groined vaults of considerable rise springing from carved stone corbels. The roof is protected from fire by light segmental vaults springing from wall to wall.

When used for flat roofing—for which purpose the strength and freedom from vibration of the construction

renders it particularly adapted—a layer of asphalte or other impervious coating is required to protect the arches from the weather.

The description of asphalte most approved for this purpose, and used by the patentees with the greatest success, is that known as the 'Pyrimont,' and supplied by the Seyssel Asphalte Company.

The formation of vaults or domes, particularly those of an ornamental character, is one of the most advantageous applications of the concrete. As no expense is involved in the cutting of groins, coffers, ribs, &c., it is in itself less costly than brick or stone, besides saving considerable expense in the strength of the outer walls, which would be required to withstand the lateral thrust of ordinary vaulting. It is moreover better adapted for decorative treatment in colour or relief.

Large vaults have recently been formed over the principal apartments of the Foreign Office. The ceiling of the principal staircase-hall, 70 feet long by 26 feet wide, is divided into three compartments, two of which are semi-cylindrical coffered vaults, and the centre one is formed as a dome, with solid pendentives. The ceiling over the Cabinet-room has a span of 36 feet; it is semicircular in form, with groined openings to the side-windows, and is divided into compartments by plain arched rims formed in the concrete. The vault itself is only 9 inches in thickness. A section of this ceiling is shown (diagram E).

The largest work upon which the Dennett system of fireproof flooring has yet been adopted is the new St. Thomas's Hospital. It is here applied in the ordinary flat-arched form to the corridors, wards, and other rooms as the foundation for the asphalte covering of the flat roofs, and as coffered vaulting in large spans to the chapel, Governor's hall, &c. Some idea of the extent of this

building may be formed when it is stated that the fireproof arching covers an area of more than eight acres.

The strength of the arches has been frequently tested by actual experiments, both as to their capacity for bearing dead pressure and with regard to their resistance to impact from falling weights, moving loads, &c. These experiments have been generally instituted by the architects upon whose works the construction has been adopted,

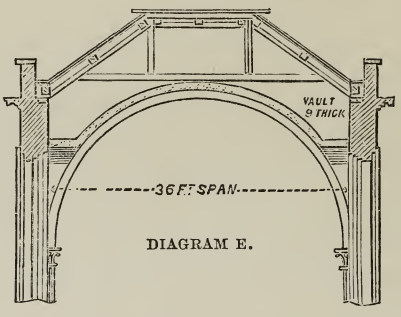


DIAGRAM E.

and they have invariably produced the most satisfactory results.

The cost of the construction varies somewhat, according to the distance from the gypsum quarries, which are almost entirely confined to the counties of Derby and Nottingham. The cost of the arching in London, in ordinary spans, as shown by diagram A, including centreing, is about 75*s.* per square of 100 superficial feet. A finished upper surface, where such is required, involves an additional expense of from 15*s.* to 25*s.* per square. These prices do not, of course, include iron girders; but as so few of these are required, as compared with other methods of fireproof construction in which concrete is used, this system will be found to possess, besides the acknowledged merits of strength, rigidity, and highly fireproof character, the advantage of economy, being from 25 to 50 per cent. cheaper than other methods.

But whatever the cost of these highly advantageous systems of construction, there are certain buildings which demand the application of the very best methods of erection in order to secure their safety from the devouring flames. In public museums and art galleries we have buildings which cannot have too much attention and money paid to make them safe; and their safety from or liability to fire is a topic of much interest. It is but seldom that one hears of a serious fire in any of these places; the truth is, though many of them would, if once a-light, make a wonderful blaze, they are generally so well watched that fire can obtain no hold without being discovered. The real danger is more from surrounding buildings being on fire than from within.

The Bodleian Library, at Oxford, about which there has been some stir lately, is a noticeable example. The building is itself highly combustible; it is filled with combustible though invaluable contents, for which there is no fireproof receptacle; and around it are other structures at least as likely to burn, and if burnt to cause the destruction of the library. Captain Galton has reported on this state of affairs, and it is now probable that one of the remedies suggested may be adopted.

A return has been made to Parliament of the state of some of the public buildings, and from the digest which has appeared in the 'Architect' I take the following:—

'The return from the British Museum acknowledges that generally, except in the basement, the materials of the building are only partially incombustible. The basement is constructed chiefly of brick, with piers and groined arches, except in a few cases, where cast-iron columns are used, the floors being either stone, slate, or cement. The principal staircases are of stone, and the smaller ones of iron. The ceilings throughout are lath-and-plaster, with fir ceiling-joists. The roofs are of wood and iron,

covered with copper, the principals being in most cases cast-iron.

'The reading-room has a cement floor, with brick arches beneath. The main ribs of the dome are iron, with brickwork between them, this being covered externally with copper, and internally with papier mâché fastened to wood ribs. The lantern is of wood and iron. The new libraries on basement and ground floors are built externally of brick, internally chiefly of iron.

'Some of the floors of the National Gallery are arched with brick, on iron girders; the floors of a portion of the rooms of the ground storey in each wing, the rooms under the dome, and others adjoining them, are of ordinary timber construction, with iron girders. The floors of the picture galleries and of most of the rooms are boarded; those of the other rooms, the entrance-halls, lobbies, staircases, and principal parts of the passages, are of stone. All portions of the floors on each storey traversed by hot-water pipes are of stone, on brick chambers, with metal gratings. The ceilings of the rooms generally are of lath-and-plaster, with fir ceiling-joists; internally the rooms are plastered or cemented, except those of the picture galleries, which are lined with wood, for dryness and facility of hanging. The roofs and lantern-lights are constructed of iron and wood, covered with lead. The lanterns of the westernmost galleries have iron shutters. Those on the top and the sides opposed to adjacent buildings are closed every night.

'At South Kensington the floors, except the official residences, are fireproof, on Fox and Barrett's principle. In the Museum they are covered with tiles or marble mosaic, and in the schools, offices, &c. in some places with wood, and others with asphalte. The floors of Bethnal Green Museum are of wood, and not fireproof, and the same may be said of the Kew Museum. The

whole of the ground floors, and in some cases the one-pair floors, of the Royal Hospital, Greenwich, are constructed on brick groined arches, and with the exception of the wood floor covering are fireproof. The remainder of the floors are of framed timbers and joists, with boarded floors, which would readily ignite. In the Edinburgh Museum of Science and Art, the whole of which is not yet completed, the greater portion of the main floor is formed of stone arches, with encaustic tiles, but the two galleries surrounding the principal halls are of wood, supported by iron columns or girders. In the east wing there is a lecture-room, with rooms, one for the exhibition of specimens, of which the floors are entirely of wood. This building would appear to be in danger if a fire occurred in any of the neighbouring premises. The National Gallery of Scotland is constructed of stonework of the best kind, and is therefore little liable to conflagration. Of museums in Dublin, the College of Science alone appears to have floors which may be considered to be incombustible. The wood in the Dublin Society's house is returned as being "very old and dry." In the Royal Irish Academy, which contains a collection of antiquities, there is but one room which is fireproof. The Hibernian Academy has also wooden floors.

'The means for prevention of fires differ much in the different buildings. The British Museum has connection with the mains, with sufficient hydrants and hose-pipes and buckets, and the tanks contain 26,000 gallons of water. There are sixteen fire-engines, six of them being kept on the roof, and two firemen are constantly on duty; besides, the police employed are drilled in the use of the engines and appliances. The National Gallery has also hydrants and hose; the tanks contain 3,900 gallons. There is only one hand-pump. There are no watchmen, and no resident officer is charged with the duty of supervision.

The care of the building is entrusted to the police. In South Kensington the arrangements to secure safety are very complete, and far superior to those in any other public building. Four-inch mains are used throughout the building and grounds, but the supply is constant only as long as the company's mains are in action. A tank in the grounds, which holds 25,000 gallons, is, however, always available, should the supply from the mains be deficient. The return says that a tower is to form part of the South Kensington building when the design is complete, and in it there are to be tanks at sufficient elevation to command the buildings by means of hydrants. Pending the erection of the tower, it is recommended that tanks to contain 50,000 gallons should be placed in the highest possible positions. There is always a fire-brigade of Royal Engineers resident on the premises, who daily examine all the appliances; and one of the assistant-directors, who is also an officer of Engineers, has the superintendence. A story is told in the Parliamentary paper which is worth giving, not only as showing that there are two ways of extinguishing a fire, but as proving the superiority of a special to a general system:—'In March 1857, at about 4.30 A.M., a fire broke out in one of the temporary wooden buildings, at that time used as art schools. The alarm was given by the police, and a man was despatched in a cab to the nearest Fire Brigade station. But before the arrival of the Metropolitan Fire Brigade engine the detachment of Royal Engineers had completely got the fire under, and had saved the contents, principally pictures, of the building. Mr. Braidwood, then Chief of the Metropolitan Brigade, on his inspection complimented the Royal Engineers on the way in which the fire had been put out. He said it was the "prettiest stop" he had ever seen, but unscientific, and that with his men he would not have attempted to extinguish the fire,

but would have directed their efforts to pulling down adjoining buildings, in order to prevent the fire spreading. The fire originated from some woodwork touching a stone, in the immediate neighbourhood of a hot air heating apparatus which had been put in by the Office of Works before the buildings were handed over to the charge of the department. Since this time the use of hot air apparatus has been discontinued, and the permanent buildings are all heated by hot water. The Geological Museum has a tank and other appliances, and the watching is wholly in the charge of the police.

'The Edinburgh Museum has an insufficient provision in water supply. In the forenoon there is no water available from the hydrants on the upper floor of the building, which is forty feet below the ridge of the roof, and there are no fire-engines. The Scottish National Gallery has six cisterns, each containing 100 gallons, but in the opinion of a superintendent of the Fire Brigade the building is adequately protected against fire. The Dublin buildings, owing to the high pressure of water supply, are supposed to be sufficiently secure without tanks.

'In nearly all of the buildings there has been hitherto no fire, and in those where there was the damage was not very great. A fire in one of the out-buildings of the British Museum, in 1865, caused a loss of a little beyond 500*l*. The fire at South Kensington has been already described. In all the buildings there is more or less constant supervision, and with this, risk is reduced to a minimum. Still the reports show how much need there is of the constant service being generally extended over the metropolis. At South Kensington, in the daytime, the pressure is usually not sufficient to command the lower roofs of the Museum buildings, and sometimes is as low as 20 feet, although at night (when there is often most danger) it rises to 160 feet.'

Respecting St. Paul's Cathedral I believe the arrangements for extinguishing fire are fairly good, but the building itself is far more combustible than most persons imagine; and though the risk of fire commencing from the interior is very slight (except when the enormous quantity of timber is introduced for seats at special festivals), there is always a certain amount of danger from the tall warehouses so closely hemming it in on all sides. The chief director of the Salvage Corps thinks it very possible that the conflagration of one of these buildings would set on fire the dome of St. Paul's, provided the building burnt freely and the wind was strong in the direction of the Cathedral. The inevitable plumber is doubtless often at work on some portion of the roof with his open fire and the mode of handling it that almost burnt Canterbury Cathedral, and thoroughly succeeded at the Alexandra Palace.

The following is from the 'Bulletin de la Société Centrale des Architectes,' 1871, communicated by the Secretary of that society to the Royal Institute of British Architects, and is most valuable, as the practical experience of the results of fires at Paris during the Commune:—

'1. Walls of freestone.—The walls constructed of freestone are seriously deteriorated, the stone being destroyed by disintegration and the calcination of the limestone. 2. Walls of rough stone.—Rubble walls, covered with a thick layer of plaster, have, owing to this preservative coating, remained unchanged, and generally they will be retained in the process of reconstruction. 3. Brick and (calcareous Sicilian) millstone walls.—Walling of these kinds has generally resisted better in cellars and underground construction; and as to the brick in partition-walls, the brick flues of chimneys remained almost intact. 4. Floors, roofs, and timber partitions.—Wood in floors and roofs has been completely consumed, but in wooden

partitions, where a coat of plaster sufficiently thick was exposed to the action of the fire, the wood has been completely preserved. Some curious facts have been the result. An angle-post having been attacked in an upper storey, the fire afterwards extended itself in the interior of the post without gaining the external surface, so that the post assumed the appearance of a pipe, the interior of which had been hollowed out by the fire.

'Oak lintels covered with plaster have resisted without injury the flames which traversed the bays of which the lintels formed the upper part. 5. Floors and roofs of iron.—Iron has not resisted the action of fire. If it has not been consumed like wood, it has undergone twisting and contortion, which render it unfit to be used again. Numerous fantastic examples have been observed, especially at the Palais de Justice, the Hôtel de Ville, and the Théâtre Lyrique. The character of iron is not to propagate combustion, but, under the influence of a very high temperature, to undergo such extension that it allows the escape of the masonry it was intended to retain.'

CHAPTER IX.

FIRE AND ITS DANGERS.

Fire, although most useful in its proper place, is the source of almost countless loss and destruction, and has well earned the character often given it, of being the best of servants but the worst of masters. Everyone knows how it has been feared by men from the world's commencement, and worshipped by idolaters even to the present day, when millions still bow down to what they fear instead of to a Being they can love.

And perhaps it is not only its destructive power that causes fire thus to be reverenced by the ignorant, and dreaded in many forms by the more enlightened. Its mysterious origin and power of spontaneously coming into existence help to characterise it as the most remarkable of the elements, and to increase the liability to dangerous results when it has fuel to feed upon.

It is not my purpose to notice the various applications of fire in ways that cause it to bring about incalculable good to mankind. A moment's thought as to what would result if fire could not be applied in numberless needful instances, and we had nothing to supply its place, will convince us that its value is far greater than all the loss it causes. But there often is loss, and to a considerable extent; and as this is generally preventable, it will be well for us to consider what are the proper means to adopt in order to guard against it.

The buildings in which fires occur most frequently are our ordinary dwelling-houses, because they largely outnumber all other classes of buildings—not perhaps because they are more liable to be burnt than others. I can find no authentic return of fires that have occurred throughout Great Britain, and therefore cannot give statistics of the relative proportions of the various kinds of structures that have been burnt. It seems to me a great mistake not to have an accurate report of every fire that happens, with full details of its cause, the damage done, &c.; the particulars might be registered more easily, and with less expense, than births and deaths are; and it is open to question if the benefit derived from such a course would not be of at least equal good. When a death results from fire the inquest often discloses facts which, if known before, might have prevented death; and it would be little trouble to arrange for the coroner or some qualified official to hold an enquiry—without a jury, of course—concerning every fire reported to him by the fire brigade in his district. If this had been done in bygone years there would not now be that ignorance of construction and of the right means of saving life and property which unhappily prevails. Why the insurance offices have not supported and carried into practice some such idea is possibly to be explained by the undoubted fact that a good fire brings them fresh business.

The number of fires is increasing rapidly every year in a proportion quicker than the increase of building or population; the explanation being that as the houses get crowded together they are more liable to be set on fire by external agency. But the increase, serious as it appears, is curiously small when one takes into account the causes, multiplying every day, by which this destruction may be effected. In the last few years London and many large towns have become intersected by railways, and the fires

and sparks of engines are frequently scattered about as if the stations and dwellings near were bomb-proof. Vessels may be seen on the Thames and elsewhere getting up steam close to the windows of warehouses with inflammable goods inside; steam, with its attendant dangers, is used in places and for purposes never thought of a short time since. Gas, with its unmistakable smell, however, making it somewhat safe, is in large use; while its modern rivals, the explosive oils, are being too carelessly used in an increasing extent. Friction-matches only a few years ago were not to be found in the houses of the poor, but are now used by everyone. The use of tobacco has extended, and there is reason to believe very many fires are due directly or indirectly to it. Stoves, instead of the open fireplaces, are in larger request, and their flues are more dangerous than the old-fashioned wide chimneys. These, and other less important facts, will explain the following statistics given in evidence by Captain Shaw before a Parliamentary Committee: 'During the 34 years since 1840, the population of London has increased from 1,907,036 to 3,342,490, or 75 per cent.; and the number of houses from 258,425 to 479,329, or 82 per cent. But during the same period the number of fires has more than doubled, having jumped from 681 to 1,548 —equal to an increase of 127 per cent. The total number of fires throughout the 34 years was 38,241.'

Only a small proportion of these 38,000 fires were very serious ones; yet the majority of them might have been so but for the precautions and appliances at hand to prevent the mischief spreading. The best way of combating this foe for the future is to ensure better house-building, and to hold an enquiry into the cause of each fire, as already suggested. But we have to deal with cities and towns already built, and with the greater part of their buildings ready to form bonfires when any care-

lessness lets even the smallest portion ignite. In another chapter I have spoken of fireproof construction, and have given instances of the danger many of our public buildings are in. But dwelling-houses are scarcely ever built to be fireproof, space and cheapness being the *desiderata*, and it will ever be so. The construction of the older ones causes them to burn out, when once fairly alight, in an incredibly short space of time, affording but little opportunity for the escape of inmates, even should they be able to withstand the choking smoke.

The following is a complete list of causes of fires in London for the year 1873:—

Airing linen	17	Flue, overheat of	10
Bleaching baskets	3	Flue, timber in	1
Boiler, overheating of	8	Flue, adjoining, defect in	15
Boiling acids	1	Flue, adjoining, foul	5
Boiling over, chemicals, oil, pitch, spirits, tar, &c.	23	Flue, adjoining, overheat of	4
Burning out paint-pot	1	Flue, copper, defect in	4
Candle	187	Flue, copper, overheat of	4
Chemicals, bottle of, breaking	1	Flue, furnace, defect in	1
Chemicals, explosion of	1	Flue, furnace, overheat of	3
Children playing with cartridges	1	Friction of machinery	6
Children playing with fire	21	Friction of vesuvians	1
Children playing with lucifers	29	Fumigating bugs	4
Clothes coming in contact with fire	7	Furnace, overheat of	5
Copper, overheat of	1	Furnace, hothouse, overheat of	1
Copper, leaking	1	Furnace, adjoining, overheat of	1
Cylinder, overheat of	1	Gas, escape of	45
Damper, defect in	1	Gasfitters at work	6
Detonating caps	1	Gasfitters at work in street	1
Doubtful	14	Gas, lighting	6
Drawing off paraffin oil	1	Gas, seeking for an escape of, in street	17
Drying apparatus, overheat of	1	Gas, swinging bracket	21
Drying-room, overheat of	1	Gaslight	2
Fire, goods placed too near	1	Gaslight, curtains or window-blinds coming in contact with	8
Fireplace blocked up	2	Gaslight, goods coming in contact with	12
Fireplace, defect in	1	Gaslight, goods placed too near	4
Fireplace adjoining, defect in	1	Gaslight, overheat of	7
Fireworks, explosion of	1	Gaslight, holly placed too near	1
Fireworks, letting off	1	Gaslight, paper blown on	1
Flue, blocked up	10	Gaslight, sunblind placed too near	1
Flue, defect in	58		
Flue, foul	24		

Glue, heating	1
Hearth, defect in	4
Hearth, fire on	4
Hearth, adjoining, fire on	2
Hot ashes	37
Hot plate, overheat of	1
Hot iron	2
Hot rivets	3
Hot soldering-iron	1
Incendiarism	11
Intoxication	6
Kiln, overheat of	2
Lamp, bag falling on	1
Lamp, lighting	1
Lamp, lighted, falling on benzoline	1
Lamp, gas, upset	1
Lamp, curtains or window-blinds coming in contact with	2
Lamp, oil, upset	1
Lamp, paraffin, explosion of	3
Lamp, spirit, upset	41
Light thrown down	115
Light thrown down area	9
Light thrown from street	19
Lighted taper	2
Lime-slaking	7
Lime slaked by rain	5
Lucifers	43
Oven, overheat of	5
Paraffin oil coming in contact with lighted candle	1
Phosphorus	3
Pipe-stove, overheat of	6
Pipe, steam, overheat of	2
Plumbers at work	3
Rags, overheat of	1
Roasting chicory	1
Smoke-hole, overheat of	1
Smoking tobacco	36
Spark from fire	172
Spark from copper fire	1
Spark from copper flue	1
Spark from copper flue adjoining	2
Spark from furnace	5
Spark from locomotive	9
Spark from oil-lamp	3
Spark from oven fire	1
Spark from smoke-hole	1
Spontaneous ignition	15
Spontaneous ignition of red fire	1
Still, overheat of	1
Still, leaking	1
Stove, overheat of	11
Stove, adjoining, overheat of	3
Stove, improperly set	4
Stove, drying, overheat of	11
Stove, drying, adjoining, overheat of	1
Stove, drying, rags falling on	1
Stove, ironing, rags falling on	1
Stove, ironing, overheat of	1
Stove, ironing, linen falling on	1
Stove, gas, overheat of	10
Sun, heat from	2
Tar-pot upset	1
Turpentine upset	1
Vapour of spirits coming in contact with flame	8
Varnish coming in contact with flame	1
Unknown	276
Total	1548

The proportion of unknown causes so frequently reported is far too large. An intelligent consideration of the circumstances which may give rise to chemical action would often solve the difficulty. There were lately reported some curious fires which occurred at Manchester, caused by the slow combustion of green wax-tapers which had been blown out but imperfectly extinguished. The smouldering wick gradually consumed away, setting the wax and surrounding materials on fire.

It has long been known that *green wax* office-tapers would thus gradually smoulder away if they are not carefully extinguished after they have been used. This danger arising from tapers may be guarded against by using any other colour than green.

Many things popularly deemed uninflammable are far from being so; for instance, tin is not a common combustible, but it will burn with considerable energy under peculiar conditions. This may be proved by placing a small portion of nitrate of copper upon a sheet of tin-foil. Both materials are inactive as long as they are dry, but upon moistening them with water the chemical action first heats the tin, which eventually will break out into flame. Lead is not usually regarded as liable to do more than melt, but under favourable circumstances it will burn with vehement heat. On the other hand, a room filled with coal-gas is by many persons supposed to be dangerously explosive, whereas it cannot even take fire excepting at the openings of the room, where, by coming into contact with the air, the necessary combination of atoms occurs so as to let the gas ignite and burn.

As most fires break out at night, the necessity is shown of examining a building at the latest possible hour. In warehouses, factories, and such like, a watchman should be employed.

The tell-tale clocks frequently used to prove whether the watchman has done his duty are of doubtful service, for it is better to rely upon an honest man's carefulness than to compel him to go certain fixed rounds which may prevent his being able to give an alarm at the right moment.

One watchman is generally best even in very large buildings. 'An instance [1] is on record in which a building

[1] See 'Fire Surveys,' p. 73.

standing in its own grounds was watched by four men, two of whom patrolled within and two without the walls, and yet the alarm of fire which happened in this building was first given by a street-constable who happened to see the light while going round his beat. If there had been but one watchman, or two, it might have been possible to impute some blame to them, but as there were four it was much more reasonable to assume that they were engaged in pegging clocks or carrying out some other so-called self-registering scheme of recording their duties instead of really transacting them.'

With regard to watching private houses this must be left chiefly to the police, but it should be seconded by an examination made by the master himself every night the last thing before retiring to rest. Many fires commence from a spark or ash falling out of the fire when it is not properly protected by a guard or fender. The habit of raking out a fire at night is a popular but mischievous one. If left to burn in the grate there is far less chance of danger than in raking out the hot ashes, which are likely to split the hearth-stone or fall on the floor or carpet. Gas-burners are dangerous when placed near the ceiling. A remarkable instance of this took place where a gas-jet set fire to a ceiling 28½ inches from it.

More attention should be paid to keeping chimneys swept, which operation should be done at regular intervals, and not left till the occupier *thinks* it is time they were done, or is reminded of it by a black shower of soot falling some wet day.

Notwithstanding that all owners of chimneys on fire can be fined for neglecting to have the flues cleaned, it has been recorded that as many as 2,435 cases of burning chimneys occurred in 1873 in London to which the firemen were called. The number is so large that the

penalty appears to be too small to effect its object, and might with advantage be increased, as the risk to property from these chimney-fires is considerable. A district in Liverpool occupied by the Irish poor is stated to have had its chimneys freed from soot by the summary process of purposely setting fire to them ; and I have read a statement giving a description of the curious sight witnessed when a whole district had its chimneys alight at once. This is fortunately not a fashionable way of 'sweeping,' but more care must be taken by those who prefer the customary mode.

Dustbins very often cause serious losses. In one instance 30,000*l.* to 40,000*l.* were lost, apparently from hot ashes being thrown into a dustbin. No heaps of rubbish or lumber of any sort should be allowed in a building of any value, and dustbins should always be placed in the open air.

The following with reference to the prevention of fires appeared in the 'Builder' for May, 1867 :—

'Keep matches in metal boxes, and out of the reach of children; wax matches are particularly dangerous, and should be kept out of the way of rats and mice; be careful in making fires with shavings and other light kindling; do not deposit coal or wood ashes in a wooden vessel, and be sure burning cinders are extinguished before they are deposited; never put firewood upon the stove to dry, and never put ashes or a light under a staircase; fill fluid or spirit lamps only by daylight, and never near a fire or light; do not leave a candle burning on a bureau or a chest; always be cautious in extinguishing matches and other lighters before throwing them away; never throw a cigar-stump upon the floor or spitbox containing sawdust or trash without being certain that it contains no fire; after blowing out a candle never put it away on a shelf, or anywhere else, until sure that the snuff has gone

entirely out; a lighted candle ought not to be stuck up against a frame-wall, or placed upon any portion of the woodwork in a stable, manufactory, shop, or any other place; never enter a barn or stable at night with an uncovered light; never take an open light to examine a gas-meter; do not put gas or other lights near curtains; never take a light into a closet; do not read in bed, either by candle or lamp light.

'The principal register of a furnace should always be fastened open; stove-pipes should be at least four inches from woodwork, and well guarded by tin or zinc; rags ought never to be stuffed into stove-pipe holes; openings in chimney-flues for stove-pipes which are not used ought always to be securely protected by metallic coverings; never close up a place of business in the evening without looking well to the extinguishing of lights, and the proper security of the fires; when retiring to bed at night always see that there is no danger from your fires.'

If these directions can all be constantly observed, we may have a tolerable sense of security.

With respect to the detection of fires there is very little to say; for though many plans for arranging electric wires, or tubes with certain chemicals inside, have been tried, I know of none that have met with general acceptance. The truth is, if there were any pressing demand for such a thing, plenty of sensible inventions would be forthcoming; but fire generally discovers itself before *anything else* would show that it existed, and therefore our energies are chiefly directed to the extinction of it when once begun.

The number of lives endangered by fire is so numerous that I feel the subject would not be complete without a few words respecting escape from a burning house. The apathy that exists as to the best means of getting safely

from such a perilous position can only be accounted for on the supposition that the probability of fire is too small to induce people to think seriously of it. But a time is likely to come in the lives of some of us when previous thought on the subject may become of enormous importance; and although at such a critical moment, when, perhaps aroused from a sound sleep, one finds oneself in a house on fire, presence of mind is the first thing required, yet a few simple suggestions that will start to the memory may be of value.

If on the first discovery of the fire it is found to be confined to one room, and to have made but little progress, it is of the utmost importance to shut, and keep shut, all doors and windows. On this particular Mr. Braidwood said: 'It may often be observed, after a house has been on fire, that one floor is comparatively untouched, while those above and below are nearly burned out. This arises from the doors on that particular floor having been shut, and the draught directed elsewhere. If the fire appears at all serious, and there are fire-engines at a reasonable distance, it is best to await their arrival, as many buildings have been lost from opening the doors and attempting to extinguish fires with inadequate means. If no engines are within reach, and you have not a hand-pump or an extincteur, the next best thing is to collect as many buckets outside the room on fire as can be obtained, keeping the door shut while more water is being collected.' Since the above was written, a valuable invention has been brought forward, by use of which a person may enter dense smoke that it would be otherwise impossible to exist in. The Smoke Respirator, which has the unattractive appearance shown by the engraving, is an apparatus to act as a filter for the separation of the pure air from an atmosphere charged with impurities detrimental to the healthy action of the lungs. It is on

the system spoken of and recommended by Professor Tyndall, in his popular lectures upon 'Dust and Smoke,' and is useful for other purposes than that already named, such as in the case of metal-grinding, or in cleaning cotton, where the operators are subject to inconvenience from particles of dust. I mention this respirator because it not only serves the firemen in entering buildings, but

would prevent many of the deaths caused in case of fire by suffocation. In lieu of this, however, a rough-and-ready protection from breathing the smoke may be had by thoroughly wetting a towel and fastening it firmly round the face over the mouth and nostrils. If I remember rightly, a man saved his life by doing this when the Star and Garter Hotel, at Richmond, was destroyed by fire.

But if the flames have too great a hold to allow of escape by the staircase or roof, and the window of the room is the only means of egress, the situation becomes a serious one, unless its possibility has been foreseen and guarded against.

Only as *the last* resource should a person run the risk of jumping to the ground; either endeavour by tying the bedclothes together to make some sort of rope, fastening one end to a heavy piece of furniture, and going down the rope hand-over-hand—a rather difficult thing to do with-

out practice—or, if within reach of one, wait as long as possible for the arrival of a fire-escape or ladder. Some people always keep a stout knotted rope in their room, and have an iron hook fixed inside the window, to which it may be affixed. This certainly gives a chance of escape, but after all it is from the *outside* that the most effectual assistance can be had. Captain Shaw's experience is that the danger to life is increasing, because of the enormous height to which buildings in London are being carried, without any precautions whatever for safety in the upper storeys. He states that a 'fire-escape such as those now in use can, immediately on its arrival, reach a height of 30 feet; after about half a minute's delay, about 40 feet; after a minute's delay, it can reach 50 feet, but it cannot reach higher; and, consequently, persons living in the lofty buildings so common in the metropolis should invariably make their own arrangements for getting down externally to spots within reach of these machines, which are at present the only means of escape available from the outside. For this purpose there are many obvious plans which might be adopted, but among these there are two which appear to be specially easy of attainment, and within the reach of all concerned, at a moderate cost. The first is to fix on buildings external ladders of wrought-iron or some other material able to resist the effects of fire at its commencement, and extending from the roof to within 40 feet of the ground; the other, to provide on every storey continuous balconies of wrought-iron or any other material proof against immediate destruction by heat; and if the balconies on the several storeys were made to communicate with each other by means of external stairs, great additional safety would be attained. Indeed, with such an arrangement it is certain that heavy loss of life would be most improbable in any fire, however rapid in its action and otherwise serious in

its results. In rows of houses the use of balconies is manifest, but even in detached buildings there can be very little doubt that, if sufficiently long, they would serve as a means of egress for those inside, and of access for those giving help from without. It may be assumed that the reason of their not being generally adopted is the double fear which owners of premises have—first, of their servants and other inmates getting out too frequently; secondly, of persons breaking in for improper purposes. But those who guard themselves from these dangers should remember at what cost they do so, and should be prepared to accept the results of a fire, causing loss of life or property, as the direct and inevitable consequence of their own state of preparation.' Captain Shaw goes on to say: 'I have always hoped to procure higher ladders than those now in use, within the limits of weight to which, for the sake of rapid travelling, I have been compelled to restrict myself; and I take this opportunity of repeating here what I have for years explained to all inventors who have come to me from various parts of the world on the subject, viz., that our present machines, the running weight of which is under 14 cwt., are capable of throwing to a height of about 50 feet, and of carrying half-a-ton weight on the weakest part when so extended, and that any machine which can be rapidly run and worked as these are by one skilled man and two unskilled assistants, and can throw to a greater height, would be considered an improvement, provided that it can safely carry the same weight and is free from any complicated gearing likely to cause delay or difficulty when subjected to rough usage in the dark.'

Mr. Wright, the Secretary of the Royal Society for the Protection of Life from Fire, has kindly placed at my disposal the following directions for saving life at fires, being the result of long and varied experience. I under-

stand he is desirous of spreading the knowledge thus gained, and will be happy to send these directions, printed on a large scale, to any person who will get them hung up where others may read and profit by them :—

PLAIN DIRECTIONS FOR AIDING ENDANGERED PERSONS TO ESCAPE FROM BUILDINGS ON FIRE, AVOIDING ACCIDENTS, AND FOR THE TREATMENT OF INJURIES.

The want of coolness and presence of mind at the time of an alarm of fire is by far the greatest hindrance to an escape, and for this no regulation can be laid down; but a few simple directions to be observed by the bystanders and inmates, well considered and reflected upon in time of safety, will in a great measure tend to discreet and successful efforts in the hour of danger.

For Bystanders.

1. Immediately on the fire being discovered give an alarm to the nearest fire-escape station, not delaying an instant; do not wait to see if it is wanted. Life is more precious than property, and events have too often proved how fatal even a moment's hesitation is in sending for the fire-escape. It is the fire-escape man's duty to proceed to the place of alarm immediately.

2. In the absence of a fire-escape, or pending its arrival, ladders and ropes should be sought for. Two constables or other qualified persons should ascend to the roof through the adjoining houses. The most efficient assistance can sometimes be rendered by an entrance to the upper part of the house on fire, either by the attic windows, the loft-door, or by removing the tiles; or sometimes the aid of one end of a rope (knotted) might be

afforded from the adjoining window, which, being passed by the person in danger round some article in the room, he could lower himself or others into the street, and the other end of the rope being controlled of course by those rendering the aid from the adjoining house. A short ladder can often be made available at the second or perhaps the third, floor of houses built with a balcony or portico, by the constable or other person first ascending to the balcony, and then placing the ladder thereon, reach the rooms above.

3. In a narrow street or court assistance may be given from the windows of the opposite house, particularly by a ladder placed across the street from window to window.

4. When no other means present themselves the bystanders had better collect bedding at hand, in case the inmates throw themselves from the windows. A blanket or carpet held stretched out by several persons will serve the purpose. The Metropolitan Fire Escape Brigade carry jumping-sheets with them for use upon emergency.

5. Do not give vent to the fire by breaking into the house unnecessarily from without, or, if an inmate, by opening doors or windows. Make a point of shutting every door after you as you go through the house.

For Inmates.

1. Every householder should make each person in his house acquainted with the best means of escape, whether the fire breaks out at the top or the bottom. Provide fire-guards for use in every room where there is a fire, and let it be a rule of the household not to rake out a fire before retiring for the night, but to leave the guard

on. In securing the street-door and lower windows for the night avoid complicated fastenings or impediments to immediate outlets in case of fire. Descriptions and drawings of fire-escapes for keeping in dwelling-houses may be seen upon application at the offices of the Royal Society for the Protection of Life from Fire, 66 Ludgate Hill.

2. Inmates at the first alarm should endeavour calmly to reflect what means of escape there are in the house. If in bed at the time, wrap themselves in a blanket or bedside carpet; open neither windows nor doors more than necessary; shut every door after them (this is most important to observe).

3. In the midst of smoke it is comparatively clear towards the ground; consequently, progress through smoke can be made on the hands and knees. A silk handkerchief, worsted stockings, or other flannel substance, wetted and drawn over the face, permits free breathing, and excludes to a great extent the smoke from the lungs. A wet sponge is alike efficacious.

4. In the event of being unable to escape either by the street-door or roof, the persons in danger should immediately make their way to a front-room window, taking care to close the door after them; and those who have the charge of the household should ascertain that every individual is there assembled.

5. Persons thus circumstanced are entreated not to precipitate themselves from the window while there remains the least probability of assistance; and even in the last extremity a plain rope is invaluable, or recourse may be had to joining sheets or blankets together, fastening one end round a bedpost or other furniture. This will enable one person to lower all the others separately, and the last may let himself down with comparatively

little risk. Select a window over the doorway rather than over the area.

6. Do not give vent to the fire by breaking into the house unnecessarily from without, or, if an inmate, by opening doors or windows. Make a point of shutting every door after you as you go through the house. For this purpose doors enclosing the staircase are very useful.

Accidents to Persons.

1. Upon discovering yourself on fire reflect that your greatest danger arises from draught to the flames, and from their rising upwards. Throw yourself on the ground, and roll over on the flame, if possible, on the rug or loose drugget, which drag under you; the table-cover, a man's coat, anything of the kind at hand, will serve your purpose. Scream for assistance, ring the bell, but do not run out of the room or remain in an upright position.

2. Persons especially exposed to a risk of their dresses taking fire should adopt the precaution of having all linen and cotton fabrics washed in a weak solution of chloride of zinc, alum, or tungstate of soda.

3. As a means for the prevention of accidents, especially where there are women and children, the provision of a fire-guard is urgently recommended. These are now made at such a reasonable price that it is incumbent upon even the poorest to obtain them. The Royal Society have it in contemplation to give orders on manufacturers at a reduced price to subscribers' recommendations.

Treatment of Injuries.

1. Send for medical aid. Let the sufferer be put to bed as quickly as possible; remove all remains of clothing

about the injured parts, cutting with extreme caution, as it is of the first importance to avoid tearing the skin or breaking a blister.

2. As the readiest thing at hand, cover all the injured parts tenderly with clean cotton or wool, what is commonly known as wadding, the cleaner and purer the better (the best for the purpose is kept by druggists); it relieves by excluding the air. Linen rag soaked in a mixture of equal parts of lime-water and linseed-oil also forms a good dressing. Common whiting is very good applied wet, and continually damped with a sponge.

3. It is better to avoid cold applications; they certainly allay pain, but unless the cold be maintained the momentary relief is followed by a considerable aggravation of the suffering. In extensive burns, moreover, cold water freely applied is not unattended by danger.

4. From thirty-six to fifty hours after the injury the blisters will present a milky appearance, and show surrounding inflammation. When this is the case they may be opened with the point of a large needle. Dressing for burns may then be simply wax and oil spread on lint; but so much depends on circumstances and the state of health of the sufferer, that it is desirable as soon as possible to secure medical attendance.

5. To recover a person in a state of insensibility from the effect of smoke, dash cold water in the face, or cold and hot water alternately. Should this fail, turn him on his face, with the arms folded under his forehead. Apply pressure along the back and ribs, and turn the body gradually on the side; then again slowly on the face, repeating the pressure on the back. Persevere with these alternate rolling movements about sixteen times in a minute, until respiration is restored. A warm bath will now complete the recovery.

As to the origin of fires, a list has already been given of the various causes of fires last year, but I may supplement it by one or two instances worthy of notice. Spontaneous combustion is often a cause of destruction, and a curious example of this was when a mass of iron filings and turnings, which had been allowed to accumulate at a large factory, ignited. The heap was sprinkled day by day with water in the process of laying the dust previously to sweeping the floor. One night, after all the men had left, a fire broke out, which was soon arrested; but was most clearly traced to the spontaneous combustion of the iron turnings. It is well known that iron decomposes water, combining with its oxygen and liberating its hydrogen, and in this case the grease on the turnings was oxydised at the expense of oxygen, condensed by the finely-divided metal, and so lent its aid in raising the temperature; and thus the heat soon reached a point that set fire to the wood in the neighbourhood.

The uselessness of covering wood with sheet or cast iron, which has been but recently shown at the Pantechnicon, was also exemplified in a fire which happened at the Bank of England many years since. The hearth on which the stove was placed was cast-iron an inch thick, with $2\frac{1}{2}$ inches of concrete underneath it, but the timber below that was fired. It is difficult to account for this unless there had been some bad workmanship or an undiscovered flaw existing in the iron or a crack in the concrete.

A rather uncommon case, although it might have been serious in its results, was that of a fire caused by an incendiary in the counting-house of a relation of mine. One night a man got access to the adjoining warehouse, and intending to steal the wages he wrongly suspected were in the office ready for paying away on the morrow, broke through the lath-and-plaster wall. With much

difficulty he got in; but, finding no plunder, in his disappointment he set fire to a heap of papers and hastened to retreat. But the hole he came in at formed, in consequence of the broken laths, a sort of eel-trap, and he was in great danger of being burnt alive. Finally he got through, the fire burnt itself out without great damage, and the burglary was discovered. The man not long afterwards was caught, and sentenced to the penal servitude he so richly deserved.

CHAPTER X.

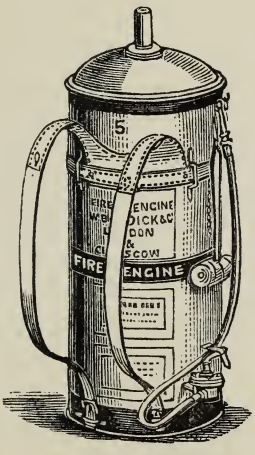
EXTINCTION OF FIRE.

One of the most primitive ways of preparing to extinguish any fire that might arise is the following rule adopted by the City of London in the reign of Richard I. 'Item. That all persons who occupy great houses have in summer time, and especially between the Feast of Pentecost and the Feast of St. Bartholomew, before their doors a barrel full of water for quenching fire, if it be not a house which has a fountain of its own.'

But there was sound wisdom in this, for the water would be at hand for instant use, and, as stated elsewhere, a gallon of water at the commencement of a fire is worth more than hundreds of gallons a little later. It is well known that a small engine at a large fire does more harm than good; and it is also well known that a small quantity of water thrown on a large amount of burning substances becomes decomposed and increases the activity of the burning. Mr. Grove has published particulars of some interesting experiments conducted by him, in which he found that water in contact with highly-heated platinum was decomposed and resolved into its elements, oxygen and hydrogen, and that the gaseous mixture thus produced burned with an activity amounting to an explosion.

Water acts in extinguishing fire by its cooling influence alone, and contains in itself the very elements of fire, so that when decomposed by a high temperature it

will burn vigorously. Thus it is that a small quantity of water thrown on a large fire often does serious mischief. The methods of extinguishing fire are two, mechanical and chemical. The use of water, for the beforenamed reasons, ranks among the former, and its most successful application is by means of the *steam fire-engine.* There are many substances that chemically oppose combustion, and perhaps the best-known medium of these for the purpose is Sinclair's *fire exterminator.* These being representatives of their respective classes, a short description may be of some value :—



The fire-exterminator appears outwardly as shown by the engraving, and is arranged so that it can be speedily and easily carried on a man's back. There are various details as to the inner structure which need not be given here, but in brief it has inside it a solution of carbonic acid gas. It may be called a large soda-water bottle charged with gas and incombustible chemicals under great pressure.

The charge of acid is contained in a glass vessel, and this is so arranged that when the machine is wanted, a

blow on the top with a mallet causes the chemicals to unite, and produce, when in operation, a stream of fluid which can be projected fifty feet against fire with certainty of success. The value of this machine is increased by the fact that a certain measure of incombustibility is communicated to burning bodies after they have been operated upon by the chemical solution. So many serious fires could be stopped in their commencement if proper means were at hand, that the importance of powerful machines in small compass, such as these, cannot be over-estimated; and their efficiency is proved by there being no less than 45,000 in use, and 6,000 fires having been extinguished by them. It is calculated by actual operations that one gallon of the chemical charge in an exterminator will do as much good as twenty-five gallons of water.

Passing to the highest type of mechanical methods now in use, we have to consider a more complete but wonderful machine, the steam fire-engine. Within the lifetime of a young man such an invention was unknown to the bulk of people, and had not come into general adoption: in its place were parish hand-engines, and a few kept up by the Fire Insurance Companies of London. There was no system under which the firemen worked, no one responsible if the engine was out of order, or any untoward accident happened; and until the great Tooley Street fire discovered the alarming possibility of another Fire of London, the public seemed well content to leave their protection from fire chiefly to chance. Some remarkable revelations concerning the state of fire-engines in these early days may be found in Mr. Young's exhaustive work on 'Fires and Fire Engines.' He gives an instance in which a woman was found to be manager of two parish engines; her husband had been sexton and parish engineer; and when he died, the parish authorities, not knowing what to do with the widow, appointed her as engineer. A writer in the

'Quarterly Review' for December 1854 relates that Mrs. Smith might be seen at conflagrations hurrying about in her pattens directing the firemen of the engine.

The present extensive application of steam-power for working fire-engines has arisen from the manifest inability of hand-worked machines to arrest the progress of large fires; from the very beneficial results that are attained by the use of steam fire-engines even at small fires; and, lastly, from the great improvements that have been made in the portable steam-engine within the last twenty years.

The first steam fire-engine was constructed by Braithwaite, of London, in 1830 (before the formation of the London Fire Brigade), but the recognition of this valuable invention as a regular fire brigade appliance did not take place till twenty-two years later, when its public use was established in New York. In the same year (1852) the London Fire Brigade employed Messrs. Shand and Mason to apply steam power to one of their hand-worked floating fire-machines, and were so satisfied with the results that they immediately procured an entirely new self-propelling floating steam-engine, constructed upon designs supplied in competition by Messrs. Shand and Mason, after receiving the approval of the late Mr. Walker, engineer, of Great George Street. This is still the most powerful efficient steam floating fire-engine that has been constructed, and is in use for river-side work in London. In 1861 the same firm supplied the first land-engine (single horizontal) purchased by the London Fire Brigade, which is still in excellent order. Many others have been since built by them, and also by Messrs. Merryweather and Sons, these two firms being the best known fire-engine makers. Steam fire-engines comprise three classes; land, floating, and fixed. The appearance of the land-engine is now familiar to all the dwellers in our large towns, most of whom have seen it in its rapid progress to a fire, drawn by horses, and

carrying its complement of firemen. Floating steam-engines are desirable in ports and docks, where warehouses and storehouses of goods are in immediate proximity to water. They are self-propelling, or are placed in a vessel to be moved about by steam tugs. Fixed steam fire-engines are placed in manufactories and other places where the steam boilers are already in use, the steam from which is available both day and night for working the engine. The use of these fixed engines is of course limited to the premises where they are situated, but these they protect efficiently by means of an arrangement of fixed cast-iron pipes, with outlets for attaching flexible hose; and being without the boiler, carriage, axles, springs, &c., of the land steam fire-engine, the cost is very much reduced.

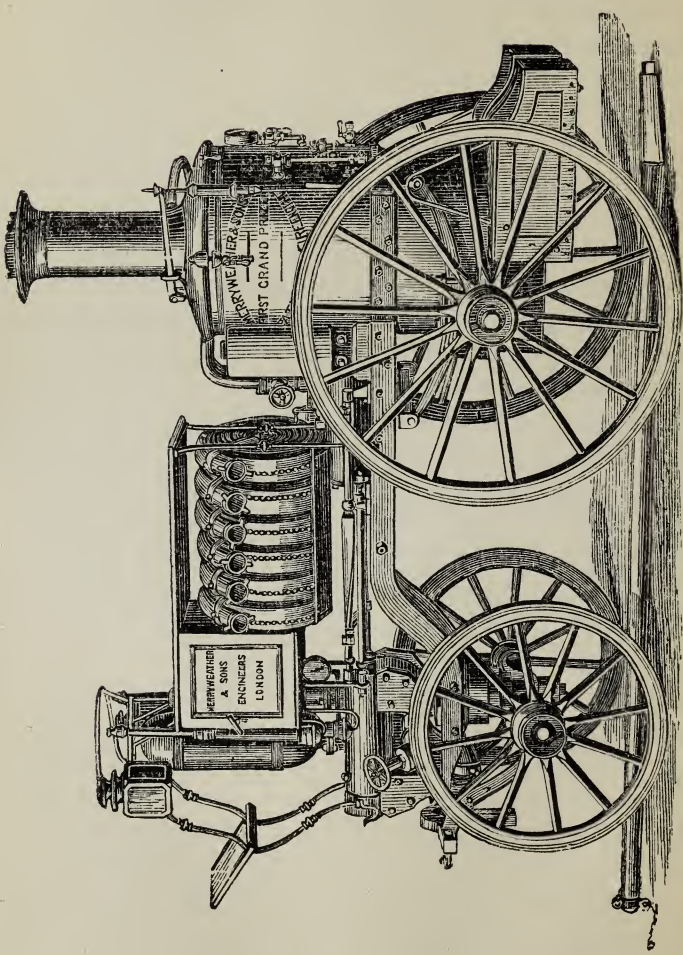
Messrs. Shand and Mason's engines (see engraving on page 127) are all direct-acting, the steam and water pistons being connected by rigid rods, without the intervention of any joints, so that the force communicated by the steam to the steam-piston is instantaneously transmitted to the water-piston without any shock or blow. A crank is used to fix the length of the stroke, and to obtain a rotary motion with which to work the slide valve by an 'eccentric,' as in the ordinary steam-engine: a small fly-wheel is used in their single vertical, but none is required in their double or treble cylinder, nor in the patent horizontal engines. A great advantage, in Messrs. Shand's opinion, attending the use of a rotary motion for steam fire-engines is, that it can be put in motion by hand in the engine-house as often as is necessary to prevent any of the working parts getting fixed through being out of use. In engines having no rotary motion this cannot be done without getting up steam, and frequently at fires the pistons have been found immovable, causing much valuable time to be lost. An engine with rotary motion does its work in a smooth and even manner, with a minimum of

attendance on the part of the man in charge, and without the shocks, jerks, and irregular movement frequently found in those constructed without it.

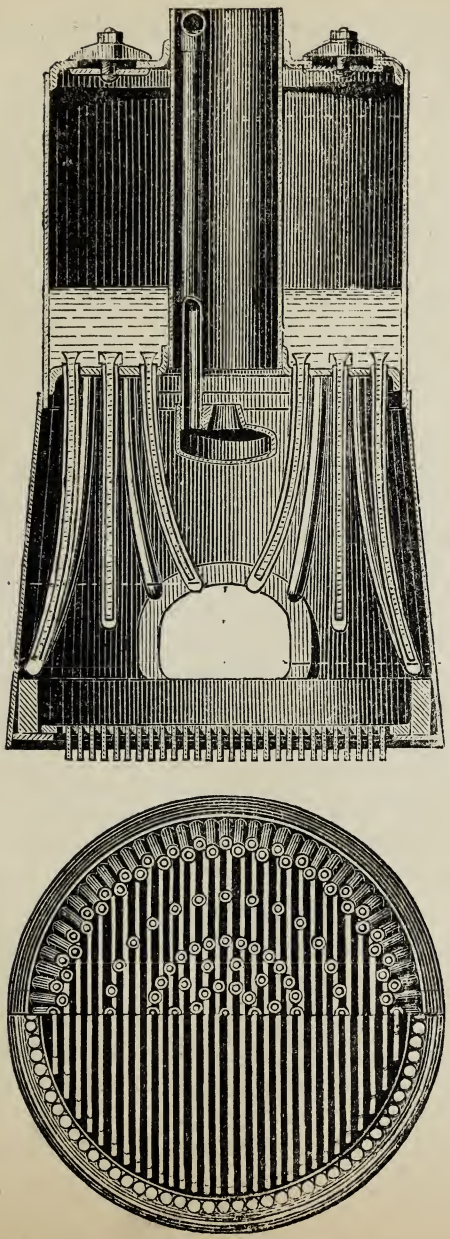
The engines made by Messrs. Merryweather are in outward appearance somewhat similar to those just mentioned, but differ in constructional detail; the rotary motion is altogether dispensed with; the power is transmitted direct; and the working parts are perhaps fewer. This firm adopts long strokes of piston, and large cubical contents of cylinders; there are no cranks or dead centres, and thus the engines are stated to do a full amount of work with lower steam pressure and at less speed. Being direct acting, without fly-wheels, they work at any required speed to the maximum; it is stated they can be started in any position, and never set fast.

The engine engraved on page 124 is named the 'First Grand Prize,' and is provided with seats for firemen, coal bunkers, water tanks, &c. It is said to raise steam from cold water to working pressure in seven to eight minutes from the time of lighting the fire; and to be capable of pumping 600 gallons per minute to a height of 180 feet. The present price of this engine, including the various fixtures and fittings, is 820*l*.

The most important part of a Steam Fire-Engine is the boiler, which should be of such a nature as to supply the greatest amount of steam in the shortest possible space of time. Messrs. Merryweather have adopted the system invented by Mr. Field, which has already for some years given such excellent results in England. The distinctive feature consists in closed tubes suspended in such a manner as to be completely surrounded by the frame of the furnace; these tubes communicate by only one extremity with the boiler: inside of them are smaller tubes, open at both ends, and with the upper ends widened out in the form of a funnel. The release of the steam produced, and



'FIRST GRAND PRIZE' PATENT STEAM FIRE-ENGINES CONSTRUCTED BY MESSRS. MERRYWEATHER AND SONS



BOILER OF MESSRS. MERRYWEATHER AND SONS' STEAM FIRE-ENGINE.

the supply of fresh water for conversion into steam, is very rapid and takes place with ease.

Messrs. Shand, Mason and Co.'s 'Patent Inclined Water-tube Boiler' is now applied by them to all Steam Fire-Engines of their construction, as well as for a variety of purposes where it is desirable to secure the greatest possible amount of power in the smallest space, combined with efficiency, economy of fuel, and durability of construction.

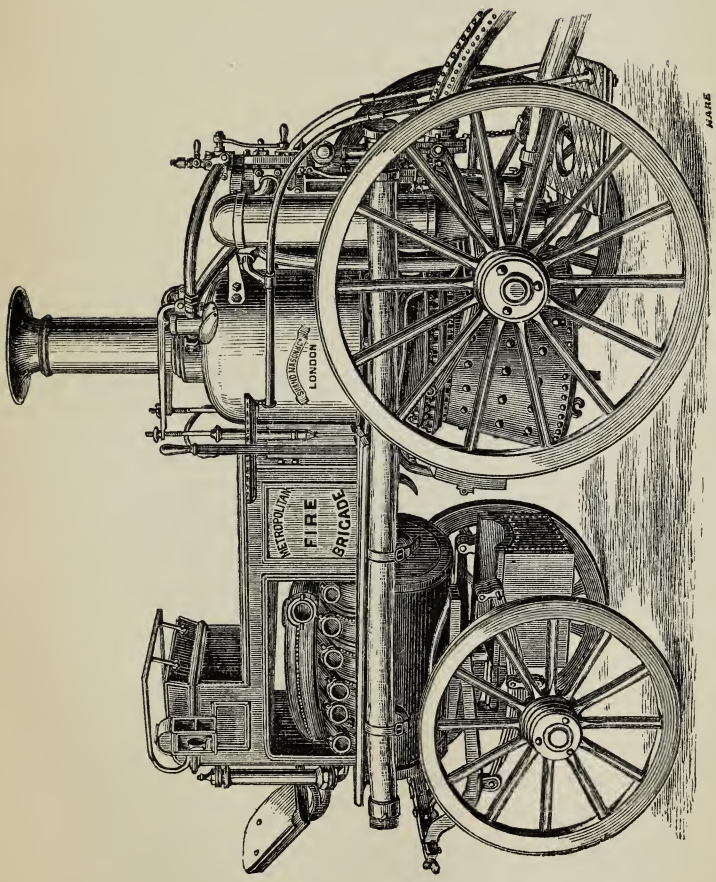
For Steam Fire-Engines, steam of 100 lbs. pressure can be raised in six minutes and thirty-five seconds from lighting the fire, while for general purposes an increase in the number of layers of tubes is made, to the extent of rendering the boiler most economical as regards fuel.

The boiler is constructed in two pieces, bolted together by an angle iron-faced joint, which affords immediate access to the whole of the interior; but on account of the rapid circulation of water in the tubes, this feature, although retained, is not found necessary in practice.

Bowling iron only is used, with the longitudinal seams welded, and all holes, whether for rivets or bolts, are drilled and not punched. The tubes are of homogeneous metal, and as the pressure is inside, and the ends are removed from the hottest part of the fire, no leakage whatever takes place, while the complete through passage in the tubes, combined with their inclined position, prevents the accumulation of deposit, which in practice invariably takes place in tubes where one of the ends is closed.

The Cylindrical Tube Plate and the tubes being exposed to equal amounts of heat, it follows that the diameter of the tube plate increases by expansion to exactly the same extent as the tubes lengthen, so that no displacement of the ends of the tubes can take place from alternate expansion and contraction.

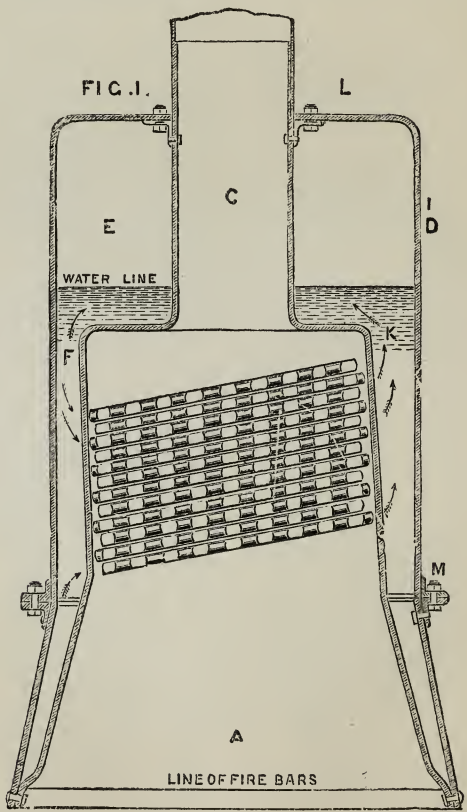
The Fire Box is surrounded by a water space, which economises fuel, and avoids the necessity for a lining of



MESSRS. SHAND, MASON AND CO'S STEAM FIRE-ENGINE; AS USED BY THE METROPOLITAN FIRE BRIGADE.

fire-bricks and fire-clay, the replacing and keeping in order of this being in some Steam Fire-Engines a fruitful source of annoyance.

The working steam pressure of Shand, Mason and Co.'s Engines in the Metropolitan Fire Brigade is 100 lbs. on the square inch, and the safety valves are constructed so that the man in charge cannot exceed this; but the boilers are



proved to 300 lbs., and the engines may be worked with the greatest safety at a pressure of 150 lbs. on the square inch.

Fig. 1 is a sectional elevation of boiler; fig. 2, an elevation of absorption chamber; fig. 3, a plan of same.

A, the furnace; B, the absorption chamber sectioned on the line I, J, fig. 3; C, the chimney or funnel; D, the outer shell; E, the steam chest; F, the narrowest part of eccentric water space through which the tubes are supplied with water at their lower ends; K, the widest part

FIG. 2.

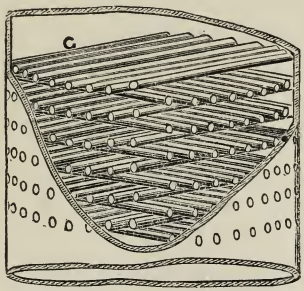
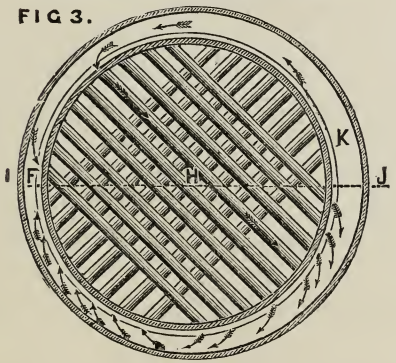


FIG 3.



of eccentric water space through which the upper ends of the tubes deliver the steam produced from the heat absorbed by the tubes, and transmitted to the water during its passage through them. By the arrangement of tubes shown at G, fig. 2, and at H, fig. 3, and water spaces shown at F and K, figures 1 and 3, a general circulation of water is obtained in the boiler, and especially through the tubes, while the water space at K increasing upwards

allows of an easy separation of steam from the accompanying water, and of its rising into the steam chest separated, thus materially preventing priming, while the water returns to the lower ends of the tubes, thereby maintaining a constant circulation through them in the direction shown by the arrows; and by crossing the tubes in alternate layers, a constant flow towards and into their lower ends is induced, and a constant discharge from the upper ends throughout the other half, thus causing general and uninterrupted currents of water and steam.

As a conclusion to the subject of Fire-Engines, I may state that, when compared with manual engines, the steam-engines show an immense saving. From a return made to the Metropolitan Fire Brigade authorities, it was proved that at a fire in St. Katharine's Docks there were nine steam-fire-engines at work from three to ten hours, the total cost of fuel being £3 18*s.* 5*d.*, while the quantity of water thrown on the fire was estimated at 938,480 gallons.

The number of manual engines required to produce the same result would be forty-one, requiring 1,904 men to work them, at a cost of £476, including refreshments, showing a balance in favour of employing the steamers of £472 1*s.* 7*d.* The proportion of the cost was as 1 to 121; or, in other words, steamers for 20*s.* expenditure pump 251,000 gallons, and manuals for the same sum only 2,227.

These Steam Fire-Engines have frequently been used for other purposes than that of quenching fire. After the Sheffield inundation, one was used for a week continuously to raise water from the basements of dwellings; and many towns have had their water-supply kept up by the use of these invaluable engines, which will no doubt come into yet more extended use.

The most that can be done after constant care has failed to prevent fire, is to rely upon extraneous help to

put it out; and this too often fails, in London at all events, because of the absurdities of the water supply. The work that can be done in attempting to extinguish a fire at an early stage is worth everything, and yet matters are so arranged that the firemen may get to a fire and watch it burning, while the turncock is sent for to find the plug and get the required supply of water; and if the pressure happens to be low in the main the supply runs short. Now this occurs at comparatively small fires; what if a whole street were ablaze, or a fire like that in Tooley Street broke out, away from the river with its friendly supply of water? Consequences of a most serious nature may result from the present system, which all persons, excepting the Water Companies, blame, and nobody alters. Constant water pressure and a good system of hydrants are urgently needed in every town. Without this the most efficient fire brigade in the world would be hampered, and it seems a crime to let anything stand in the way of the full development of the energy displayed by fire brigades like that in London—certainly the best in existence. By the kindness of its chief I am enabled to supply a few particulars about this energetic body of men, to whom the public are so indebted, and of the work they perform.

The strength of the brigade at present is as follows:—

50 Fire-engine stations.
105 Fire-escape stations.
4 Floating stations.
53 Telegraph lines.
85 Miles of telegraph lines.
3 Floating steam fire-engines.
1 Iron barge, to carry a land steam fire-engine.
5 Large land steam fire-engines.
16 Small land steam fire-engines.

15 Seven-inch manual fire-engines.
56 Six-inch manual fire-engines.
12 Under six-inch manual fire-engines.
125 Fire-escapes.
396 Firemen, including the chief officer, the superintendents, and all ranks.

The number of firemen employed on the several watches kept up throughout the Metropolis is at present 90 by day and 181 by night, making a total of 271 in every 24 hours; the number of those sick, injured, on leave, or under instruction, is generally between 40 and 50. The remaining men are available for general work at fires.

The number of journeys made by the fire-engines, during the year 1873, of the 50 stations, was 6,556, and the total distance run was 20,503 miles.

The number of calls for fires, or supposed fires, received during the year was 1,703. Of these, 83 were false alarms, and 1,548 were calls for fires, of which 166 resulted in serious damage, and 1,382 in slight damage.

These figures refer only to the regular calls for fires, or supposed fires, involving the turning out of firemen, fire-engines, horses and coachmen; they do not include trifling damage by fires which were not sufficiently important to require the attendance of firemen; neither do they include the ordinary calls for chimneys on fire, which are separately accounted for further on.

The fires of 1873, compared with those of 1872, show an increase of 54; but compared with the average of the last ten years there is a decrease of 17.

The proportion of serious to slight losses in 1873—166 to 1,382—is about as favourable as hitherto.

The following table gives it both in actual numbers and percentages, and shows that there was considerable success in reducing losses during the year.

Years	Numbers			Percentages		
	Serious	Slight	Total	Serious	Slight	Total
1866	326	1,012	1,338	25	75	100
1867	245	1,152	1,397	18	82	100
1868	235	1,433	1,668	14	86	100
1869	199	1,373	1,572	13	87	100
1870	276	1,670	1,946	14	86	100
1871	207	1,635	1,842	11	89	100
1872	120	1,374	1,494	8	92	100
1873	166	1,382	1,548	11	89	100

The number of fires in the Metropolis in which life was seriously endangered, during the year 1873, was 74, and the number of these in which life was lost was 20.

The number of persons seriously endangered by fire was 140, of whom 105 were saved and 35 lost their lives. Of the 35 lost, 12 were taken out alive, but died afterwards, in hospitals or elsewhere, and 23 were suffocated or burned to death.

The number of calls for chimneys was 3,602, of these 1,167 proved to be false alarms, and 2,435 were for chimneys on fire. In these cases there was no attendance of engines, but only of firemen with hand-pumps.

The quantity of water used for extinguishing fires in the Metropolis during the year was 22,610,379 gallons, in round numbers a little more than 22½ million gallons, or about 101,000 tons. Of this quantity 66,113 tons, or almost exactly two-thirds of the whole, were taken from the river, canals, and docks, and the remainder from the street pipes.

During the year there were 6 cases of a short supply of water, 29 of late attendance of turncocks, and 17 of no attendance, making altogether 52 cases in which the water arrangements were unsatisfactory.

The monthly summary of fires for the same year is as follows :—

Month	Seriously damaged	Slightly damaged	Total
January	8	102	110
February	11	98	109
March	14	102	116
April	14	120	134
May	17	118	135
June	16	129	145
July	20	139	159
August	18	118	136
September	11	107	118
October	18	102	120
November	6	105	111
December	13	142	155

Many a damaging fire has been stopped by the *immediate* application of water, and many more would have been if a little common sense and presence of mind were oftener displayed. As a simple precaution in one's own house, always keep the bedroom water-jugs full, and have an exterminator in a handy place ready for immediate use. For places liable to fire—and what building is not—this latter handy instrument, with its peculiar liquid, is invaluable, its contents being worth several times the same quantity of water. For some purposes it is better than the pumps and portable engines so largely employed, and is always a valuable addition to them; the effects I have witnessed of its operation are so remarkable that its general adoption should be only a matter of time.

Country mansions need special appliances for putting out fire, which are determined by the style of building, its position, whether or not near a good water supply, &c., but all the fixed apparatus should not supersede the little engines just mentioned. A large mansion in Hampshire, burnt not long since, was specially constructed with a view to have a good water supply in case of fire; the tank at the top to charge fixed pipes being kept full by a pump, and everything else possible done to ensure safety. But

the fire broke out when the pump was out of order, and no water could be had, and so the house that took years to build was burnt in a few hours. No precautions, however ample or costly, can be reckoned on unless constant supervision is exercised over them, and care taken to keep the various appliances ready for action.

The destruction of Messrs. Hadley's great steam flour mill in Thames Street, close to Blackfriars Bridge, did not fail to call attention to the problem of protecting large buildings from fire. The 'Engineer' of November 1872 states that the mill was erected in 1852. It had a frontage of 65 feet to the river, was 250 feet long, and 7 storeys high. Originally the machinery was driven by the condensing side lever engines which were specially designed and built to work the Blackwall Railway with ropes, a duty they performed for several years. About four years ago these engines were replaced by a pair of fine compound horizontal condensing engines, capable of working up to about 500 horse-power. The mill was considered to be fireproof, and no doubt deserved the title as well as many of the so-called fireproof buildings in London and the provinces. The fire broke out in one of the upper floors, some time on Sunday morning, Nov. 10, 1872, and in a very few hours the mill, with the exception of the outer walls, and portions of the lower part, was utterly destroyed. At one time no fewer than thirty engines were present; eighteen of them, including the Thames floating engine, being steam-engines.

A correspondent of the 'Builder' stated that the following mills were destroyed by fire in four consecutive weeks in 1872. Oct. 26, Waterloo Cotton Mills, loss £30,000. Hyson and Sharpe's Cotton Mills, Blackburn, £6,000. Nov. 14, Dean's Cotton Mills, Swinton, £10,000. Nov. 10, Hadley's Mill, London, say £20,000. Nov. 15, Parker's Cotton Mills, Preston, £16,000. Nov. 18, Whate-

ley's Cotton Mill, Aberdeen, £18,000. Nov. 22, Bury and Heap's Cotton Mills, £10,000. Nov. 23, Gomersall Bros. Woollen Mills, Dewsbury, £15,000. Total loss, £132,000.

In reckoning the losses occasioned by fire, we cannot, however, confine ourselves to the mere cost of the building; the wages lost by workpeople thrown out of employ, the trade gone into other hands, and possibly never recovered —these, and other considerations, should lead to extreme care being taken to prevent fire, and to having proper appliances at hand to extinguish it, if, unfortunately, it breaks out.

APPENDIX.

Description of the Plan and Section of Fireproof Warehouse.

The photo-lithographs of a fireproof warehouse are from drawings by Mr. E. Hoole, architect; and it will be seen that these concise designs embody the principles enunciated in the preceding chapters.

A building for the reception of combustible goods must not only be constructed of materials that will not burn, but must be so built that it will remain uninjured, even if its contents are destroyed by fire. Like a furnace, it must be made to contain a fire; and it is only a building which, under such circumstances, maintains its strength, that is entitled to be termed fireproof.

In the accompanying plan and section, brick is proposed as the material for the construction of the walls and floors. These are so arranged as to divide the building into eighteen separate compartments, each of which is so completely cut off from those which surround it, that a fire originating in any one of them might burn itself out without being able to spread to the next one.

The interior of each compartment is so constructed that it will not be damaged by the combustion of its contents. It is assumed that it will be subjected to intense and continued heat; and the same precautions are taken to secure the stability of the structure and protect it from injury as would

be adopted in building a furnace or in setting a boiler. Each compartment is lined with fire-brick, which is here and there attached to the walls to keep it in position, but not sufficiently to communicate the heat it may receive.

Between the fire-brick lining and the building itself an air space is left, which the heat cannot traverse. This lining bears no part of the weight, either of the building or of its contents; and consequently, however hot it may become, it cannot be crushed or distorted, having only its own weight to sustain. This fire-brick lining is set in fire-clay.

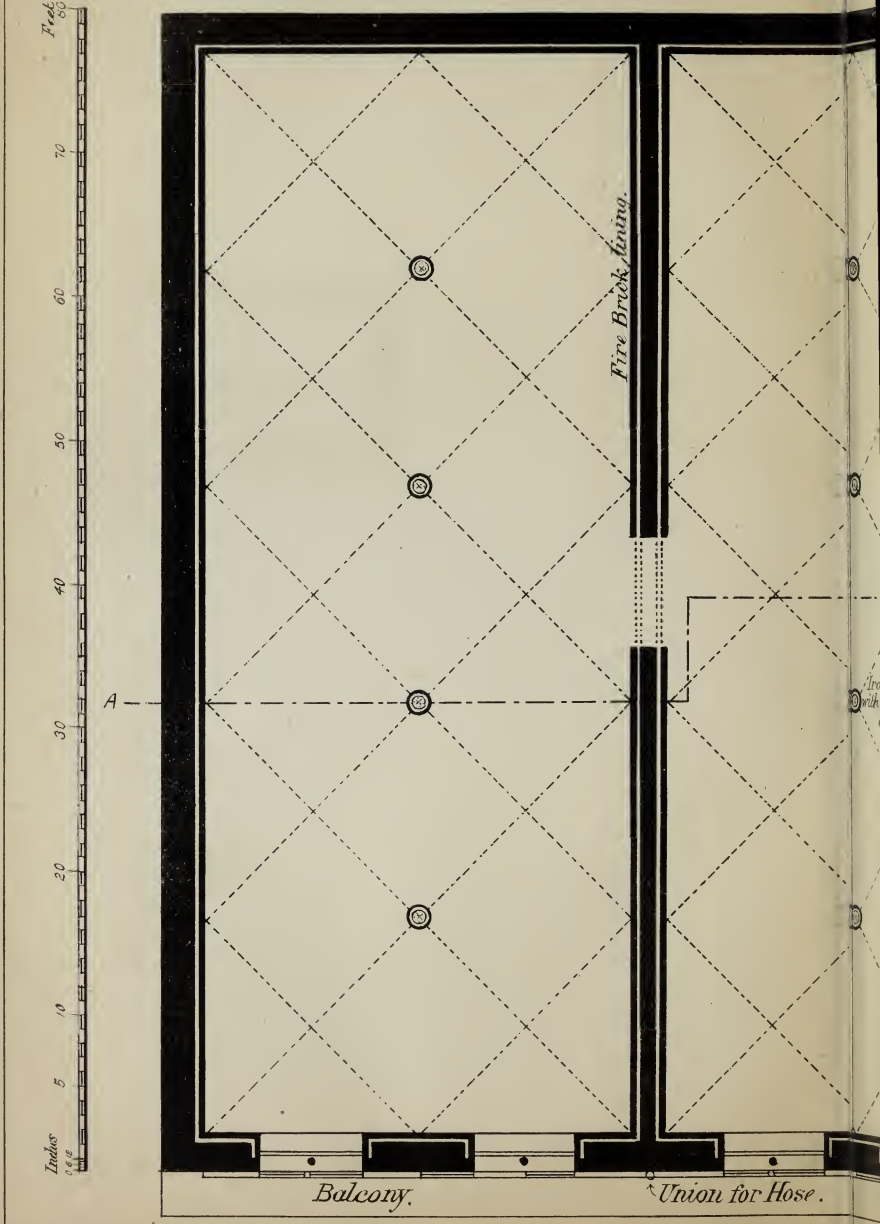
Iron columns filled with concrete support the vaulting of the various floors, and are protected by a casing of fire-brick, between which and the column an air space is left. In warehouses in which the brick casing of the columns is likely to be damaged by the shifting of the goods it can itself be protected by a covering of sheet-iron. But this, of course, is no additional safeguard against the action of fire.

The thrust of the vaulting is counteracted by iron tie-bars embedded in the brickwork below the flooring of each compartment; the ends of the bars are well turned up and down in the external walls, besides being connected to the brickwork near the base of each column. It will be seen that all parts of the building which have to sustain any weight are protected from any great change of temperature, and that all iron-work is especially screened from it.

In constructing the staircase the same precautions are adopted. A wall carried up the centre affords a springing for the arches carrying the steps and landings, which are constructed entirely of brick, and may be covered either with tiles, stone, or even wooden treads, if desired. The thrust of the arches carrying the steps is overcome by building in a tie-bar above each arch, which thus protects it from any contact with fire.

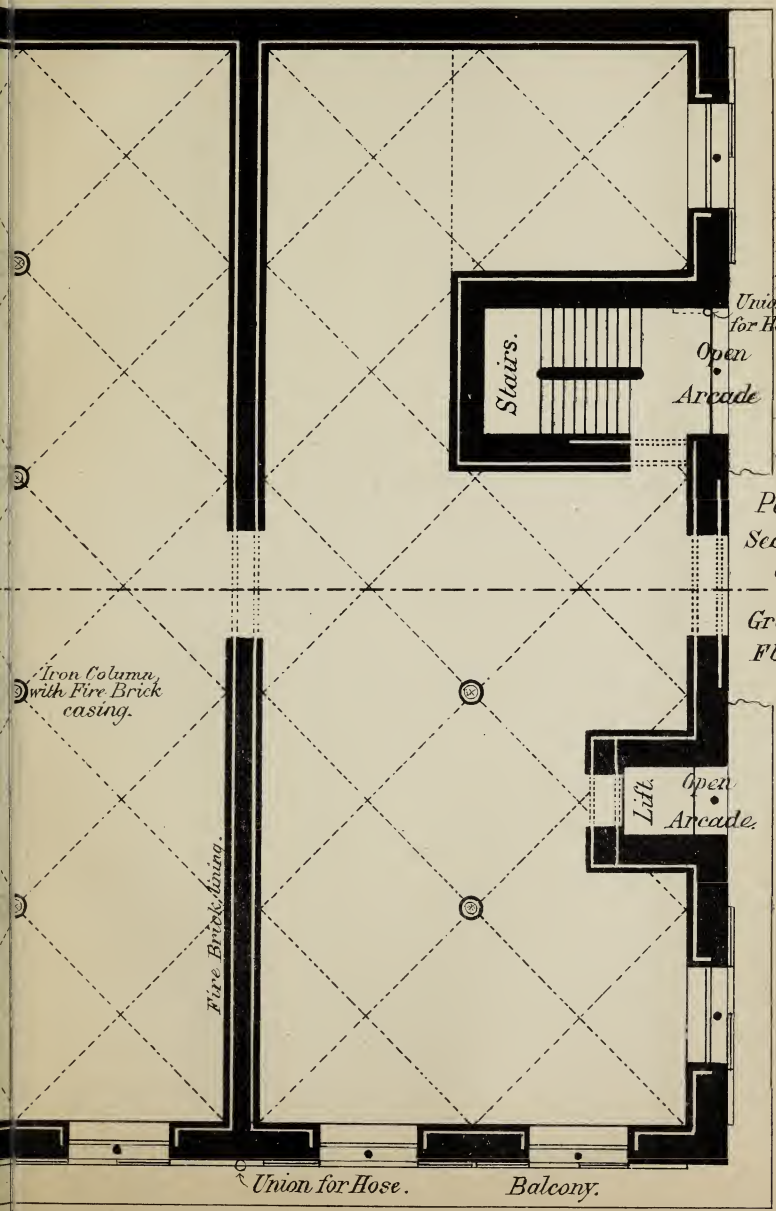
In order to prevent the staircase from acting as a flue in case of fire, and causing a draught of air to rush through the parts of the building opening into it, one side of it is left open to the external air, being only enclosed by a light arcade of open arches on each floor. Thus it gains the advantage of

FIREPROOF WAREHOUS



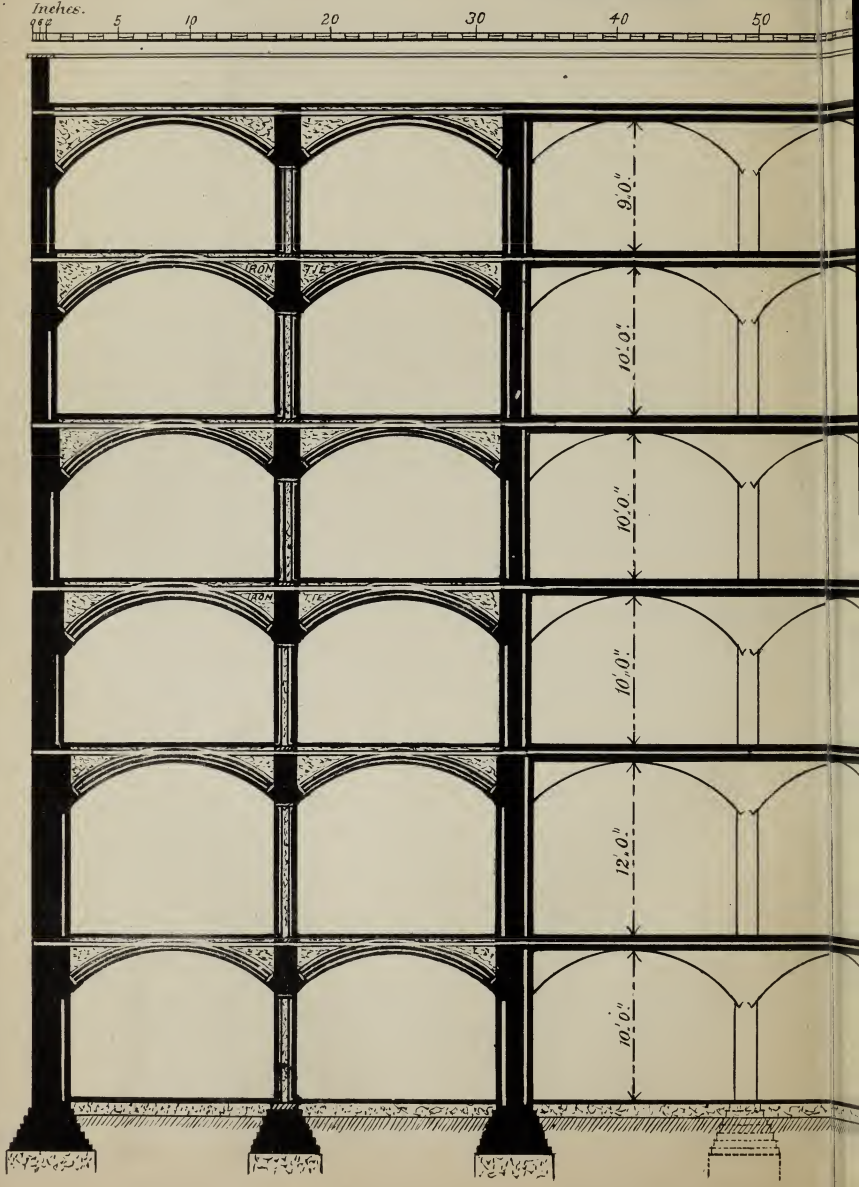
M&N.HANHART, LITH.

PLAN OF FIRST FLOOR.



E. HOOLE. ARCHT.

FIREPROOF WAR



Section thro' Columns and Section

IOUSE. SECTION.

60 70 80 90 Feet. 100

TANK.

Balcony.

Section thro' Stairs.

Balcony.

hro' Doorways on Line A.B.

E. HOOLE, ARCHT.

an outside staircase, all the doors leading to it being treated as external doors. The lift is similarly treated.

Double iron doors, lined or cased with heat-repelling material, separate the various compartments on each floor from the staircase and from each other. These doors are so arranged that they can be closed from the external balconies, and thus any compartment in which a fire occurs can be isolated without the necessity of entering it, or indeed of entering the building.

The windows are closed by external sliding shutters, running upon rails projecting from the outside face of the walls. These shutters are so constructed that they can be opened by the firemen from the outside; and easy access is given to them by the balconies, which are carried round the building at the level of every floor. Iron balconies are shown on the plan and section, since in most cases the heat issuing from the windows will not be sufficient to affect its strength; but where very inflammable goods are to be stored it will be best to corbel out in the brickwork, and to arch from corbel to corbel to form the balconies. Permanent means of access to the exterior of every opening in the walls is a most important provision, allowing any part of the building to be inspected independently, and fire discovered or extinguished, without opening the doors of the adjoining compartments.

The roof is nearly flat, having but fall enough to carry off the water. It may be made water-tight by a layer of asphalte, and then paved with tiles; but a flat roof is not an essential feature of fireproof construction, since, if the ceiling be vaulted in brick, as shown, a roof of any pitch may be constructed above it, framed entirely of iron, and covered with slates tied by copper wire to iron laths, or with metal tiles. It is obvious that nothing combustible must be stored in the space between the roof and the ceiling.

A tank is shown at one angle of the roof, to contain a supply of water in case of fire, and it can be kept full by the ordinary means of supply of the neighbourhood. If a portion of the top storey can be given up for the purpose, the rain-water of the roof can be stored without incurring a water-rate. From the tank, pipes are conducted outside the building

and furnished with unions near the windows of each compartment; so that a hose-pipe can be instantly attached by any-one standing in the balcony, and the whole contents of the tank discharged into any of the compartments, without the building being entered.

In the case of a fire occurring in any compartment, two methods of proceeding are available. The compartment can be isolated and completely shut up until the fire either burns itself out or is extinguished for want of air; or the shutters can be opened, and a larger quantity of water can be discharged upon the burning goods, immediately the fire is discovered.

Patents for Locks and Safes.

The want of a complete list of the patents taken out from time to time for Locks and Safes has induced me to publish the following tables, which have been most carefully compiled from the Patent Office records. It has been impossible to give even a summary of the claims made by each patentee of locks, on account of the space which would be thus occupied; but I have endeavoured to increase the usefulness of the lists by distinguishing between expired and unexpired patents. For the detailed particulars of each I must refer the enquirer to the specifications themselves, which can be purchased at the Patent Office, near Chancery Lane, London. An inspection of these will astonish many persons who may not be prepared to find the same inventions patented several times. But such is the case; and if patents are necessary as a protection to inventors (which I am somewhat inclined to doubt), the system adopted ought certainly to be such as would avoid the heavy fees ever being paid for an invention already secured to another person.

From the list of Patents for Locks I have omitted all such as are merely fastenings for railway-carriage doors, for hand-bags, pocket-books, &c., or for windows. I have also not included the 'furniture' of locks, *i.e.* the handles, spindles, &c.,

but all locks and latches used for doors will be found in the list.

The list of Patents for Safes includes all parts of, or apparatus connected with, Fire and Thief-resisting Safes.

Those marked * had either Provisional Protection only, or (in a few cases) were void for want of filing the complete specification. Those marked † lapsed at the end of three years from the date given in the lists; and those marked ‡ lapsed at the end of seven years. Those without any mark and not in italics ran their full term and expired at the end of fourteen years.

Only in the instances wherein the patentee's name is in italics are the patents now (December 1st, 1874) in force.

In the list of Safes, wherever the patents are in some respects similar to previous inventions, a reference to such invention is appended.

LIST OF PATENTS FOR LOCKS AND LATCHES USED AS FASTENINGS FOR DOORS.

Year	Day	No. of Patent	Name
1774	May 27	1071	Black, George
1778	Oct. 31	1200	Barron, Robert
1779	May 28	1226	Henry, Solomon
1780	March 4	1247	Ampion, John
1782	Jan. 18	1317	Hutchinson, Samuel
1784	April 2	1430	Bramah, Joseph
1789	July 7	1692	Cornthwaite, Thomas
1790	Feb. 23	1730	Rowntree, Thomas
,,	Oct. 29	1778	Bird, Moses
1791	July 19	1819	Ferryman, Robert
,,	Nov. 3	1835	Antes, John
1795	Aug. 28	2062	Spears, James
1797	Nov. 18	2203	Langton, Daniel
1798	May 3	2232	Bramah, Joseph
,,	Dec. 8	2277	Turner, Thomas
1799	April 11	2306	Davis, George
1801	June 23	2521	Holemberg, Samuel
1805	May 18	2851	Stansbury, Abraham Ogier
1808	Dec. 29	3188	Tompson, William
1813	May 15	3695	Bullock, William, and Boaz, James
1815	March 7	3891	Mitchell, William, and Lawton, John
1816	May 14	4027	Ruxton, Thomas
,,	,, 27	4036	Kemp, Robert
1817	Feb. 1	4096	Higginson, George Montague
,,	,, 8	4101	Clark, William
1818	,, 3	4219	Chubb, Jeremiah
,,	June 30	4275	Roux, Albert
1819	Oct. 18	4402	Strutt, Antony Radford
1820	April 11	4443	Jennings, Henry Constantine
,,	Dec. 14	4519	Mallet, William
1823	July 10	4812	Fairbanks, Stephen

Year	Day	No. of Patent	Name
1823	Nov. 13	4862	Ward, John
1824	June 15	4972	Chubb, Charles
1825	May 14	5171	Young, John
1828	,, 17	5656	Chubb, Charles
1829	June 1	5798	Gottlieb, Andrew
1830	Jan. 18	5880	Carpenter, James, and Young, John
1831	April 14	6105	Rutherford, William
,,	May 23	6116	Barnard, George
,,	July 27	6143	Young, John
1832	Dec. 20	6350	Parsons, Thomas
1833	,, 3	6516	Parsons, Thomas
,,	,, 20	6527	Chubb, Charles, and Hunter, Ebenezer
,,	,,	6532	Pierson, Josiah Gilbert
1834	Sept. 6	6674	Longfield, William
,,	Oct. 11	6694	Audley, Lord Baron
1835	March 18	6792	Hill, Richard
,,	Dec. 16	6960	Warrick, John
1836	Feb. 10	7000	Fenton, Samuel
1838	June 30	7715	Uzielli, Matthew
,,	Nov. 13	7872	Thompson, Sally
1839	Feb. 21	7972	Uzielli, Matthew
,,	June 12	8106	Sanders, Joseph
,,	July 3	8140	Cochrane, Alexander
,,	,, 20	8163	Schwieso, John Charles
,,	Aug. 1	8181	Williams, William Morrett
,,	Dec. 2	8293	Guest, James
1840	Feb. 27	8402	Williams, William Morrett
,,	March 20	8440	Gerish, Francis William
,,	May 2	8489	Peirce, William
,,	June 13	8543	Wolverson, Joseph, and Rawlett, William
,,	Oct. 22	8666	Clark, Thomas
,,	Dec. 23	8747	Baillie, Benjamin
1841	March 29	8903	Tildesley, James, and Sanders, Joseph
,,	May 6	8953	Hancock, James
,,	July 14	9029	Berry, Miles
,,	Sept. 28	9104	Strong, Theodore Frederick

Year	Day	No. of Patent	Name
1841	Nov. 9	9144	Smith, Jesse
1842	Jan. 15	9224	Poole, Moses
,,	May 24	9364	Duce, Joseph
,,	June 13	9395	Williams, William Morrett
,,	Dec. 29	9578	Rock, Joseph, jun.
1843	Nov. 25	9963	Tann, Edward, Edward, and John
,,	,,	9965	Rock, Joseph, jun.
1844	Jan. 30	10032	Fletcher, William
,,	May 14	10182	Pitt, Benjamin
1845	April 15	10611	Carter, George
1846	March 25	11152	Cotterill, Edwin
,,	July 6	11283	De La Fons, John Palmer
,,	,, 15	11299	Thomas, William
,,	Dec. 14	11491	Chubb, John
1847	Jan. 11	11523	Chubb, John, and Hunter, Ebenezer
,,	April 16	11659	Collett, Charles Minors
,,	Sept. 16	11869	Hancock, William
1848	,, 28	12274	Newall, Robert Stirling
1849	May 8	12604	Wilkes, Samuel
1850	July 22	13184	Bradford, James
1851	April 15	13595	Newell, Robert
,,	Nov. 4	13802	Dismore, George
,,	,, 6	13806	Parnell, Michael Leopold
,,	,, 13	13807	Sinclair, William
,,	,, 22	13824	Restell, Thomas
,,	Dec. 8	13852	Restell, Thomas
1852	Feb. 23	13985	Hobbs, Alfred Charles
,,	Oct. 21	472	†Rose, Joseph
,,	Nov. 23	828	†Parnell, Michael Leopold
1853	Jan. 21	160	†Chubb, John, and Goater, John
,,	,, 29	229	†Whishaw, Francis
,,	Feb. 11	367	†Choppin, William
,,	May 3	1074	†Goble, George Frederic
,,	,, 23	1266	†Simson, William
,,	,, 27	1310	‡Bentley, William Henry
,,	July 5	1600	†Tripe, Decimus Julius
,,	,, 6	1617	†Newton, William Edward
,,	Aug. 11	1866	*Rushbury, John
,,	,, 18	1932	†Pigé, Alexis

Year	Day	No. of Patent	Name
1853	Sept. 9	2076	‡Parnell, Michael Leopold
,,	,, 9	2077	*Martin, James
,,	Nov. 7	2587	‡Newton, Alfred Vincent
,,	,, 21	2698	†Tucker, Walter Henry, and Reeves, Rashleigh
,,	Dec. 10	2879	*Du Bost, Hippolyte Laurent
,,	,, 22	2980	†Gibbons, James, Jun.
1854	Feb. 1	256	†Daniel, Alfred
,,	,, 20	405	Milner, William
,,	March 1	505	†Holland, John Simon
,,	,, 2	514	†Tann, John
,,	June 12	1288	‡Young, John
,,	July 1	1441	*Jones, Robert Lewis
,,	,, 11	1514	†Wolverson, Edwin
,,	Aug. 1	1697	†Holland, John Simon
,,	,, 4	1709	‡Miles, Louis Player
,,	Sept. 2	1917	†Lewis, George
,,	,, 25	2060	McConnel, Robert
,,	Oct. 3	2122	†Newton, William Edward
,,	Dec. 9	2592	*Button, Reuben
,,	,, 12	2611	†Larkin, Richard
,,	,, 13	2616	†Stansbury, Charles Frederick
,,	,, 20	2684	Milner, William
,,	,, 23	2712	*Giroux, Barthélemy Martin
1855	Jan. 29	218	†Imray, John
,,	April 25	934	†Bellford, Auguste Edward Loradoux
,,	May 1	978	*Wright, Lemuel Wellman
,,	,, 11	1063	†Henderson, Constantine
,,	,, 21	1127	Tucker, Walter Henry
,,	June 9	1315	Nettlefold, J. S., E. J., and J. H.
,,	July 18	1623	†Scully, Vincent, and Heywood, Bennett John
,,	Aug. 13	1837	†Butler, Thomas
,,	,, 15	1851	†Avery, John
,,	,, 30	1959	*Stansbury, Charles Frederick
,,	Sept. 4	2001	†Mueller, Charles Gustav
,,	Nov. 14	2572	†Newton, Alfred Vincent
1856	Jan. 21	156	*Fenton, Samuel
,,	Feb. 5	310	‡Parnell, Michael Leopold

Year	Day	No. of Patent	Name
1856	March 28	744	†Daniel, Alfred
,,	April 21	950	*Dortet, Jules
,,	,, 24	989	Blacket, Frank William
,,	June 18	1436	‡Tucker, Walter Henry
,,	July 1	1544	*Newton, Alfred Vincent
,,	,, 18	1690	†Leuchars, William
,,	Aug. 7	1860	*Weber, Lionel
,,	Dec. 11	2944	‡Miles, William Player
,,	,, 26	3066	*Newburgh, Sidney, and Steinhart, Charles
1857	Jan. 8	68	‡Harris, James
,,	,, 15	120	†Hobbs, Alfred Charles
,,	April 2	916	†Morrison, Duncan, and Lilley, Samuel
,,	,, 15	1070	Safran, Jacob
,,	May 6	1284	†Newton, William Edward
,,	,, 12	1331	*Cotterill, Edwin
,,	July 13	1942	*Hinks, Joseph Lester, and Day, John Rock
,,	,, 28	2059	†Dortet, Jules, and Dénis, André Barthélemy
,,	Dec. 24	3160	†Hart, George William
1858	Jan. 20	94	†Nixon, Christopher Nugent
,,	,, 21	110	Wilson, Peter; Northall, Samuel; and James, Thomas
,,	Feb. 23	355	†White, George Frederick
,,	March 31	682	†Duce, Joseph Warner
,,	May 24	1160	*Hamilton, George, and Nash, William Henry
,,	June 11	1332	†Hart, George William
,,	,, 30	1470	*Wheatcroft, William Smith, and Smith, James Newton
,,	July 6	1513	*Davies, John Taylor
,,	Sept. 1	1989	†Newton, William Edward
,,	Oct. 5	2212	Hamilton, George, and Nash, William Henry
,,	,, 11	2263	*Platt, Joseph
,,	Nov. 9	2506	*Henry, Michael
,,	,, 11	2533	†Newton, Alfred Vincent
1859	Jan. 17	132	†Brooks, Edward

Year	Day	No. of Patent	Name
1859	March 16	660	†Ash, Isaiah
,,	,, 16	669	*Hamilton, George, and Nash, William Henry
,,	April 27	1059	*Hamp, Charles
,,	May 7	1149	‡Henry, Michael
,,	,, 17	1228	†Law, Charles
,,	,, 26	1302	†Young, John
,,	June 23	1513	*Prince, Alexander
,,	Aug. 13	1869	*Clegg, Robert Dawson, and Saunders, Thomas
,,	,, 17	1895	†Brooman, Richard Archibald
,,	Oct. 14	2343	‡Price, George
,,	Nov. 25	2672	†Tildesley, Matthew
1860	Jan. 2	2	†Luis, Jozé
,,	,, 6	43	†Fowler, John
,,	,, 11	78	†Newton, Alfred Vincent
,,	March 5	598	†Price, Cyrus
,,	April 24	1021	*Brodie, James
,,	,, 27	1071	*Withers, George
,,	May 11	1153	‡Price, George
,,	,, 16	1208	†Newton, William Edward
,,	,, 28	1308	*Chatwood, Samuel*[1]
,,	June 2	1360	†Newton, William Edward
,,	,, 15	1460	*Mackrow, Isaac
,,	,, 19	1487	*Brooman, Richard Archibald
,,	,, 26	1550	*Hudson, Wm. Henry, and Evans, John
,,	July 17	1731	‡Loysel, Edward
,,	Aug. 23	2032	†Spence, William
,,	Sept. 8	2172	*Hoare, Deane John
,,	,, 15	2250	†Newton, William Edward
,,	Nov. 2	2685	‡Hamilton, George
,,	,, 16	2827	*Morrison, Alfred
,,	Dec. 13	3071	‡Chubb, John, and Hunter, Ebenezer
1861	Feb. 9	324	*Grimshaw, O'Donnell
,,	,, 18	401	†Price, Cyrus and Elihu
,,	April 10	882	*Morel, Auguste Victor
,,	May 2	1098	†Winkler, Michael
,,	June 19	1577	†Pradel, Peter

[1] Extended until 1879, by Judicial Committee of Privy Council.

Year	Day	No. of Patent	Name
1861	July 22	1835	*Mennons, Marc Antoine Francois
,,	,, 24	1850	*Hirschfeld, Ferdinand
,,	,, 30	1902	*Hart, John Matthias*
,,	Aug. 5	1943	†Brooman, Richard Archibald
,,	Sept. 5	2206	‡McConnell, Robert
,,	Nov. 20	2915	‡Croxford, Joseph Cooper
,,	Dec. 17	3159	†Tucker, Walter Henry
1862	Jan. 20	140	*Mappin, Walter Sandell*
,,	,, 25	200	†Lefort, François Joseph Lalmand
,,	March 15	723	*Hamilton, George*
,,	April 12	1057	*Sweet, Andrew
,,	,, 19	1145	†Loysel, Edward
,,	May 5	1328	‡Allman, Herbert
,,	,, 17	1504	*Tessier, Charles Hippolyte
,,	June 17	1791	*Pringle, Archibald
,,	Oct. 13	2750	†Chatwood, Samuel
,,	,, 16	2791	*Berry, George
,,	,, 16	2796	*Harold, Thomas George
,,	,, 27	2889	†Pilgrim, Thomas
,,	Dec. 15	3349	†Phelps, William
1863	Jan. 9	73	†Tucker, Walter Henry
,,	,, 13	109	*Tildesley, Matthew
,,	,, 15	131	†Barraclough, Thomas Critchley
,,	,, 26	228	*Smith, Andrew
,,	Feb. 7	347	*Parigot, Claude, and Grivel, Antoine*
,,	,, 16	417	†McEntee, Withers, and Withers
,,	March 26	790	†Parnell, Michael Leopold
,,	April 14	934	*Berry, George
,,	,, 15	951	*Morton, John Sanderson
,,	,, 16	959	†Oldfield, William
,,	July 8	1702	†Newton, William Edward
,,	Nov. 5	2742	*Hancock, Henry, and Vickers, William Henry
1864	Jan. 5	28	‡Fenby, Joseph Beverley
,,	Feb. 13	379	†Bedford, Joseph
,,	March 12	633	*Hancock, Henry, and Vickers, William Henry
,,	July 6	1679	†Von Rathen, Antony Bernhard
,,	Sept. 6	2174	†Weaver, Frederick
,,	,, 27	2367	*Adams, Arthur John

Year	Day	No. of Patent	Name
1864	Oct. 5	2446	†Bonneville, Henri Adrien
,,	Nov. 25	2954	*Newton, Alfred Vincent
1865	Jan. 11	92	*Heather, John Fry
,,	March 1	570	†Whitfield, Samuel
,,	,, 20	778	*Chatwood, Samuel*
,,	April 4	944	*Nabbs, Richard
,,	,, 7	999	*Kimberley, Nathan Gold
,,	,, 12	1043	*Walker, John*
,,	,, 12	1045	*Hart, John Matthias*
,,	,, 29	1194	*Tucker, Walter Henry
,,	,, 29	1201	†Clark, William
,,	May 22	1402	*Gedge, William Edward
,,	,, 22	1406	*Hodson William
,,	,, 27	1462	†Diele, Ludwig
,,	,, 30	1485	*Grafton, Sidney
,,	,, 30	1487	†Calvert, John
,,	June 9	1578	‡Meek, G. E., and Howes, W. H.
,,	,, 29	1735	†Newton, William Edward
,,	July 6	1782	†Carter, George
,,	,, 8	1812	†Heather, John Fry
,,	,, 21	1902	*Walton, James*
,,	Aug. 12	2092	†Newton, William Edward
,,	,, 26	2198	*Hodgson, Edmund Dorman*
,,	Sept. 28	2484	†Price, Cyrus
,,	Nov. 4	2852	†Gardner, William
,,	,, 8	2879	†Rainé, Jules Adolphe
,,	,, 21	2991	‡Pope, Frederic
,,	Dec. 9	3169	*Grivel, Antoine, Jun.
,,	,, 23	3324	*Groves, Joseph, and Robinson, George, Jun.
,,	,, 30	3382	†Newton, William Edward
1866	Jan. 6	48	†Tolhausen, Frederick
,,	March 17	799	†Hinton, Frederic
,,	April 20	1118	†Allen, James
,,	June 4	1545	†Fenby, Joseph Beverley
,,	,, 12	1597	*Kurz, Frederick William
,,	,, 16	1635	*Macdonald, Archibald
,,	,, 16	1638	*Hopps, George Henry
,,	July 2	1750	†Bonneville, Henri Adrien
,,	Nov. 14	2987	*Clark, William

Year	Day	No. of Patent	Name
1866	Dec. 29	3420	*Adams, Arthur John
,,	,, 31	3441	*Allman, Herbert
1867	March 8	654	†Pope, Frederic
,,	,, 29	937	†Wolverson, Joseph, Jun.
,,	May 6	1326	†Lake, William Robert
,,	,, 7	1353	*Saxby, Henry John
,,	July 27	2184	†Jones, Thomas
,,	Nov. 9	3166	†Hall, Samuel, and Whittingham, Maurice
1868	Feb. 7	422	†Lake, William Robert
,,	,, 26	651	*Dowell, William and James
,,	March 27	1061	†Hughes, Henry, and Jones, Charles
,,	April 4	1144	*Nabbs, Richard*
,,	,, 27	1372	*Tidmarsh, Samuel
,,	June 5	1842	†Clark, Alexander Melville
,,	,, 8	1874	†Coffey, Dominic
,,	July 11	2199	†Brooman, Clinton Edgcumbe
,,	Sept. 8	2764	†Fraser, Alexander John
,,	Oct. 15	3153	†Gumpel, Charles Godfrey
,,	Nov. 23	3549	†La Penotière, William
,,	Dec. 3	3676	†Maréchal, Louis Jules
,,	,, 14	3796	*Brooman, Clinton Edgcumbe
,,	,, 21	3887	†Whitaker, Richard
1869	April 22	1245	†Lake, William Robert
,,	,, 27	1293	†Lake, William Robert
,,	June 18	1878	*Andrew, Matthew
,,	Sept. 8	2636	†Hodges, Richard Edward
,,	,, 11	2672	*Andrew, Matthew
,,	,, 15	2700	*Clark, Alexander Melville
,,	,, 30	2846	†Dewe, John
,,	Oct. 12	2963	†Andrew, Matthew
,,	Nov. 11	3250	†Lake, William Robert
,,	,, 11	3256	*Harris, William*
,,	,, 11	3257	*Wilson, Peter*
,,	,, 15	3290	†Brampton, Frederick
,,	,, 16	3300	*Tucker, Walter Henry*
1870	Jan. 21	187	*Whitfield, Frederic*
,,	April 30	1242	*Massi, Charles
,,	July 7	1927	*Murdoch, Hunter Henry
,,	Sept. 9	2440	*Tildesley, James*

Year	Day	No. of Patent	Name
1870	Oct. 22	2785	*Samels, Abel Edgar*
,,	Nov. 26	3108	†Murdoch, Hunter Henry
,,	,, 28	3114	†Abel, Charles Denton
,,	,, 28	3115	†Abel, Charles Denton
,,	Dec. 22	3356	*Morrison, James*
1871	Jan. 12	87	*Pocock, Alfred Willmer*
,,	,, 30	240	†Lawrence, Charles Lewis
,,	Feb. 1	265	*Harvey, Henry Cummins, and Walton, Thomas
,,	May 1	1160	†Imray, John
,,	June 8	1514	*Hutchins, Henry Edward
1872	Jan. 25	252	*Mills, Benjamin Joseph Barnard*
,,	March 22	881	*Brolly, William Stuart*
,,	May 18	1523	*Pichery, Jules Léandre
,,	July 10	2074	*Lancaster, Henry*
,,	Aug. 20	2472	*Brodie, James*
,,	Sept. 18	2764	*Osborn, William
,,	Oct. 5	2940	*Kromer, Theodore*
1873	March 21	1057	*Morgan-Brown, William*
,,	May 29	1932	*Fox, Howard Busby*
,,	June 26	2219	*Mansbridge, Thomas*
,,	July 25	2545	*Greenwood, Henry Brown
,,	Aug. 25	2793	*Hunt, Bristow*
,,	Sept. 16	3029	*Edwards, John
,,	,, 19	3081	*Harrington, John*
,,	,, 27	3159	*Vaughan, Henry
,,	Oct. 24	3453	*Ratcliff, Daniel Rowlinson*
,,	,, 31	3550	*Chatwood, Samuel*
,,	Dec. 17	4139	*Barton, Charles*
1874	Jan. 3	44	*Harrington, John*
,,	Feb. 19	642	*Worrell, Thomas Boyle*
,,	March 5	818	*Clarke, Henry*
,,	,, 30	1095	*Whitworth*
,,	April 16	1320	*Turner*
,,	,, 21	1377	*Wheeler*
,,	,, 29	1495	*Rutter*
,,	June 6	1974	*Faddy*
,,	,, 23	2174	*Titley*

LIST OF PATENTS FOR SAFES, ETC., AND APPARATUS FOR PROTECTING THE CONTENTS OF THE SAME.

Year	Day	No. of Patent	Name	Chief Claims
1801	Feb. 10	2477	Scott, Richard	Fireproofing
1834	,, 13	6555	Marr, William	Fireproofing
1835	May 1	6832	Chubb, Charles	Case-hardening plates
1839	June 11	8100	Chubb, Charles and Jeremiah	Well safes
1840	Feb. 26	8401	Milner, Thomas	Fireproofing
1843	Nov. 25	9963	Tann, Edward; Edward, Jun., and John	Fireproofing. A disclaimer afterwards published of certain parts
1851	March 3	13540	Milner, William	Fireproofing and bolts
1853	Nov. 7	2587	Newton, Alfred Vincent	Chilled cast-iron
1854	July 12	1533	*Gardissal, Charles Durand	For postage and other stamps
,,	Dec. 20	2684	Milner, William	Wood for lock-cases
1855	Jan. 31	236	Price, George	Painting interior and case-hardening exterior
,,	Aug. 21	1888	†Longsdon, Robert	Hydraulic apparatus
,,	Nov. 22	2632	†Price, George	Steam-tight chests
1856	April 24	989	Blacket, Frank William	Fixing locks and detachable heads to keys

1856	Aug. 16	1919	†Lilley, Samuel	Chilled cast-iron. (Newton, 1853, No. 2587.)
1857	Jan. 20	172	†Johnson, John Henry . . .	A ship safe
,,	April 16	1075	*Crook, Samuel Thomas . . .	Casting and welding
,,	Sept. 25	2481	‡Chubb, John	Steel plugs and corrugated steel
,,	Nov. 25	2947	*Hogg, James	Revolving shutter for door
1859	March 21	717	†Rhodes, William	Water for fireproofing
1860	April 27	1071	*Withers, George	Welding iron and steel plates, &c.
,,	May 28	1308	*Chatwood, Samuel* [1] . . .	Fluid metal run in between two plates
,,	Sept. 13	2211	*Price, George	Coating doors with steel
1862	Jan. 29	232	*Pulvé, Louis Alexandre . . .	Wool and sand fireproofing
,,	Oct. 13	2750	†Chatwood, Samuel . . .	Tee-iron frame. Nine claims
,,	Dec. 12	3327	*Winiwarter, George . . .	Fireproofing. Tubes bound with straw, clay, &c.
1863	March 3	594	‡Price, George, and Dawes, William	Angle-iron frame. Electro-gilding lock
1864	Oct. 10	2485	†Gardner, William	False bottom
1865	Jan. 9	71	†Wiese, Friedrich	Fireproofing (Milner, 1840, No. 8401)
,,	Feb. 6	326	†Shaw, Robert	Shop-window safe
,,	,, 9	364	†Chubb, John	Recessed door, &c.
,,	,, 15	439	*Clark, Alexander	Chilled cast-iron, &c. (Lilley, 1856, No. 1919.)

[1] Extended until 1879, by Judicial Committee of Privy Council.

Year	Day	No. of Patent	Name	Chief Claims
1865	Feb. 16	450	*Thompson, Joseph*	Solid flanges, &c.
,,	,, 17	459	*Fergusson, James	Sliding doors
,,	,, 22	499	†Shore, George Nathaniel	Curved edge to door
,,	,, 23	507	*Whitfield, Samuel*	Screw-bolts
,,	,, 23	508	‡Mappin, Walter Sandell	Flanged plates and rivets
,,	,, 23	514	*Taylor, Henry Kinden	Exposed safe
,,	,, 27	543	*Tucker, Walter Henry	Casting and welding
,,	,, 28	559	*Hart, John Matthias*	Holding bolts
,,	March 2	585	*Chatwood, Samuel*	15 claims. (Shore, 1865, No. 499; and Whitfield, 1865, No. 507.)
,,	,, 6	619	‡Varley, Cromwell Fleetwood	Electric apparatus
,,	,, 6	621	*Phillips, Samuel, and Groves, Joseph	Undercut angle-iron, &c.
,,	,, 8	653	*Taylor, Arthur Edwin	Sliding door
,,	,, 9	660	‡Harris, Joseph Thomas	Fire-resisting doors
,,	,, 11	695	‡Tann, John	Ten claims
,,	,, 13	702	†Hill, Henry	Sliding door. (Taylor, 1865, No. 653.)
,,	,, 14	714	†Hodgson, Edmund Dorman	Sliding door. (Hill, 1865, No. 702.)
,,	,, 15	728	*Loysel, Edward	Spiegel-eisen, &c. (Chatwood, 1865, No. 585.)
,,	,, 31	903	*Milner, William, and Ratcliff, Daniel Rowlinson	Ribs, hooks, &c.
,,	,, 31	904	†Cook, Thomas	Circular door

1865	April 4	946	*Thompson, George Curr . .	Screw-bolts. (Chatwood, 1865, No. 585; Whitfield, 1865, No. 507.)
,,	,, 7	1000	†Skidmore, Thomas . . .	Inner angle-iron frame
,,	,, 12	1045	*Hart, John Matthias* . . .	Actuating bolts
,,	,, 13	1056	*Chubb, John, and Goater, Robert	Projections on door
,,	June 20	1657	†Parish, James; Thatcher, Charles; and Glasscock, Thomas . .	Dovetailed door
,,	July 22	1911	†Diaper, William	Z iron frame; revolving steel rods. (Tann, 1865, No. 695.)
,,	Aug. 2	1995	*Andrew, Thomas; and Taylor, James Whiteley. . . .	Screw-bolts. (Thompson, 1865, No. 946, &c., &c.)
,,	,, 2	2006	†Allman, Herbert	Chilled cast-iron, &c. (Thompson, 1865, No. 450.)
,,	,, 11	2081	†Kjellberg, Peter Carlsson . .	Suspended safe
,,	,, 17	2121	†Phillips, Samuel; and Groves, Joseph	Dovetails, curved edge, &c. (Chubb, 1865, No. 1056; Shore, 1865, No. 499.)
,,	Sept. 2	2265	*Chatwood, Samuel*	Casting with soft metal
,,	,, 7	2294	‡Hart, John Matthias . . .	Joining plates by metal in tubes
,,	,, 9	2318	†Nordenskiöld, Adolf Eric, and Smith, John William. . .	Connecting safe with water-pipes

Year	Day	No. of Patent	Name	Chief Claims
1865	Sept. 26	2457	*Parigot, Claude, and Grivel, Antoine	Locking apparatus
,,	Nov. 20	2979	*Fenby, Joseph Beverly	Expanding bolt
,,	Dec. 1	3085	*Batho, William Fothergill	Stamped safe
,,	,, 9	3169	*Grivel, Antoine	Keyless lock, &c.
,,	,, 21	3305	†Blackman, John William	Connecting safe with water-pipes. (Nordenskiöld, 1865, No. 2318.)
,,	,, 23	3321	‡Chatwood, Samuel	Casting safes
,,	,, 23	3324	*Groves, Joseph, and Robinson, George	Projecting pieces, &c. (Phillips, 1865, No. 2121.)
1866	Jan. 11	96	*Rudling, William Atkins	Electric apparatus
,,	Feb. 21	541	*Deakin, William	Projections on doors, &c. (Groves, 1865, No. 3324.)
,,	,, 23	552	†Haddan, J. C., and Haddan, H. J.	Circular safes, and vitrifying exterior
,,	March 2	641	‡Tansley, James	Interlocking doors
,,	,, 3	648	*Hosking, Albert	Gaslight detector
,,	,, 6	685	†Chubb, John	Tie-bars, rivets, and hinges

1866	March 7	694	†Price, George	Plate-iron frame projections, &c. (Tann, 1865, No. 695.)
,,	,, 9	717	*Moxon, Thomas Bewsher . .	Electric apparatus
,,	,, 13	754	†Jessop, Joseph, and Warburton, William	Serrated edge to door
,,	,, 17	792	†Sagar, Thomas, and Keighley, George	Cylindrical safe. (Haddan, 1866, No. 552.)
,,	,, 17	799	†Hinton, Frederic	Circular door. (Sagar, 1866, No. 792.)
,,	,, 27	895	*Bracher, John	Frame and angle-iron
,,	,, 29	911	†Noake, Reuben	Joining edges. (Bracher, 1866, No. 895.)
,,	,, 31	930	†Hindshaw, George . . .	Serrated door, &c. (Jessop, 1866, No. 754.)
,,	April 4	954	*Maddocks, John, and Dunn, William	Sliding doors and dovetailed bars
,,	,, 19	1106	‡Evans, Daniel	Welding and joining plates. (Hart, 1865, No. 2294.)
,,	May 16	1387	†Gisborne, John Sacheverell . .	Electric and clockwork apparatus
,,	,, 16	1390	†Price, Elihu and Cyrus . . .	Moveable bars; fireproof inner door
,,	June 7	1570	*Grivel, Antoine*	Nine claims. Locking apparatus
,,	,, 11	1587	*Baxter, John, and Hunt, John .	Serrated door and casting safe. (Hindshaw, 1866, No. 930; Tucker, 1865, No 543.)

Year	Day	No. of Patent	Name	Chief Claims
1866	June 12	1598	*Kurz, Frederick William . .	Double sliding-doors. (Maddocks, 1866, No. 954.)
,,				
,,	,, 22	1671	†Peyton, Edward	Circular door
,,	Aug. 1	1977	†Billing, Edwin Isaac . . .	Spherical safe
,,	,, 2	1993	*Chillcott, Isaac Eldon . . .	Serrated door. (Baxter, 1866, No. 1587, and others.)
,,	,, 22	2152	†Minns, Henry Royall . . .	Claw-bolts, and fireproofing. (Milner, 1840, No. 8401.)
,,	Sept. 3	2256	†Hosking, Albert Whitford . .	Gaslight detector. (Hosking, 1866, No. 648.)
,,	Nov. 3	2856	*Chubb, John*, and *Chalk, William Henry*	Diagonal bolts, and overlapping frame
,,	,, 7	2894	†Goodbrand, Walter, and Holland, Thomas Eccles . . .	Gaslight detector. (Hosking, 1866, 2256.)
,,	,, 22	3064	*Nicholson, James	Overlapping door
,,	Dec. 12	3265	‡Chatwood, Samuel . . .	Locking apparatus
1867	Jan. 23	176	*Pinney, John	Chilled casting. (Tucker, 1865, No. 543.)
,,	,, 29	229	‡Snell, William	Water fireproofing. (Rhodes, 1859, No. 717.)

1867	Feb. 13	400	†Westwood, Jos., and Baillie, Robt.	Rebated door, &c. (In use many years before.)
,,	June 14	1741	*Bryant, Hezekiah Hazard . .	Water fireproofing. (Snell, 1867, No. 229.)
,,	Aug. 19	2382	*Cowper, Edward Alfred . .	Welding plates
,,	Sept. 25	2696	*Ratcliff, Daniel Rowlinson . .	Angles dovetailed to bars
1868	Jan. 1	2	†Lake, William Robert . . .	Spherical safe, &c.
,,	,, 29	307	†Snell, William	Wood fireproofing, &c.
,,	March 18	926	*Wailes, George	Joining angles
,,	April 22	1311	*Fiddes, Augustine, and Curtis, Charles John	Locking apparatus. (Chubb, 1857, No. 2481; Price, 1863, No. 594; Diaper, 1865, No. 1911.)
,,	,, 30	1415	*Chatwood, Samuel*	Welding plates, &c. (Cowper, 1867, No. 2382; Chubb, 1866, No. 2856; Bracher, 1866, No. 895.)
,,	June 17	1971	†Rhodes, William and James . .	Frames. (Chubb, 1865; No. 1056; Chubb, 1866, No. 2856.)
,,	July 15	2228	†De Bergue, Charles, and Haddan, John Coope . . .	Circular safes, &c.
,,	Aug. 7	2469	*Curtis, Charles John*, and *Fiddes, Augustine*	Skeleton frames, revolving rods, &c. (Diaper, 1865, No. 1911; Price, 1866, No. 694; Wailes, 1868, No. 926.)

Year	Day	No. of Patent	Name	Chief Claims
1869	April 5	1026	*White, William George*	Hooked bolts, and trough iron. (Minns, 1866, No. 2152; Chubb, 1866, No. 2856.)
,.	May 6	1399	*Hart, John Matthias*	Jointless body; hooked bolts, &c. (White, 1869, No. 1026.)
,,	,, 19	1552	*Fuller, William Frederick	Screw night-bolt
,,	Sept. 22	2759	*Minns, Henry Royall*	Hooked sliding bolt. (Minns, 1866, No. 2152.)
,,	Nov. 24	3388	†McNeill, Andrew	Floating safe
,,	Dec. 9	3564	†Ballou, Russell Arnold	Lampblack fireproofing
1870	Jan. 19	162	*Mawe, William	Circular screw door
,,	March 9	694	*Duffey, James	Fireproofing. (Bryant, 1867, No. 1741; Snell, 1867, No. 229; Rhodes, 1859, No. 717.)
,,	May 5	1289	*Johnson, John Henry*	Fireproofing; steam safe
,,	June 7	1648	*Schäfer, Frederick	Steel shutter
,,	July 14	1992	*Curtis, Charles John, and Fiddes, Augustine	Fireproofing. (Johnson, 1870, No. 1289.)
,,	,, 29	2132	†Minns, Henry Royall	Locking apparatus. (Minns, 1869, No. 2759.)
,,	Oct. 6	2654	*Chatwood, Samuel, and Tobin, Thomas William	Air chambers, &c.

1870	Nov. 1	2876	†Newton, William Edward . .	Electro-magnetic apparatus
1871	May 5	1221	*Ratcliff, Daniel Rowlinson* . .	Compound hooked bolt
,,	July 6	1761	*Farrel, John*	Spiegel-eisen, angle-frame, &c. (Chatwood, 1865, No. 585; Price, 1863, No. 594.)
,,	Nov. 16	3108	*Haseltine, George*	Electro-magnetic apparatus
,,	,, 18	3128	*Corliss, William*	Spherical safe. Fourteen claims
1872	Feb. 14	458	*Cottam, Edward	Supporting safes
,,	,, 20	542	*Nickson, Philip Henry Hammond	Mica lining. (Snell, 1868, No. 307.)
,,	March 4	668	*Fothergill, Benjamin*, and *Rumble, Thomas William* . . .	Constructing safes. (See all patents relating to steel, chilled iron, &c.)
,,	May 28	1611	*Hobbs, Alfred Charles*, and *Hart, John Matthias*	Use of steel, &c. (Fothergill, 1872, No. 668.)
,,	July 6	2048	*Elwell, James Fenton*, and *Grove, Joseph*	Knuckle-bolts
,,	,, 12	2103	*Chambers, John Wilkinson . .	Electric signals
,,	Oct. 7	2953	*Gardner, William*	Securing safe to floor
1873	Jan. 15	165	*Hipkins, Edward*	Tee-iron frame, &c. Chatwood, 1862, No. 2750; Tann, 1865, No. 695.)
,,	,, 17	194	*Perman, Charles Hayward*, and *Whitaker, Richard* . . .	Lids of boxes

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Year	Day	No. of Patent	Name	Chief Claims
1873	Jan. 18	226	*Lake, William Robert* . . .	Water fireproofing. (Duffey, 1870, No. 694, &c.)
,,	May 21	1846	*Chatwood, Samuel*	Air-pipes round safe
,,	June 9	2048	*Whichcord, John*, and *Anderson, William*	Constructing safes. (Fothergill, 1872, No. 668.)
,,	,, 10	2050	*Hayward, Walter Frank* . . .	Angles and doors. (Phillips, 1865, No. 621; Phillips, 1865, No. 2121; Chubb, 1866, No. 2856; Price, 1863, No. 594; Price, 1866, No. 2121.)
,,	,, 19	2149	*Easton, Edward; Pole, William; and Whichcord, John . .	Doors sliding by hydraulic pressure
,,	Sept. 18	3065	*Cottam, Edward*	Series of safes
,,	Nov. 13	3689	*Fear, Henry, and Wilson, Peter .	Hinges and hooked bolts. (White, 1869, No. 1026, &c.)
,,	Dec. 10	4066	*Taunton, John Richard Cromwell* .	Rotating steel discs
1874	Jan. 24	320	*Chubb, George Hayter*, and *Chalk, William Henry*	Fixing lining, and locking apparatus. (Chubb, 1866, No. 2856.)
,,	Feb. 13	552	*Goater, John*	General construction. Ten claims
,,	June 10	2029	*Brannon.*	

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